The Engineer

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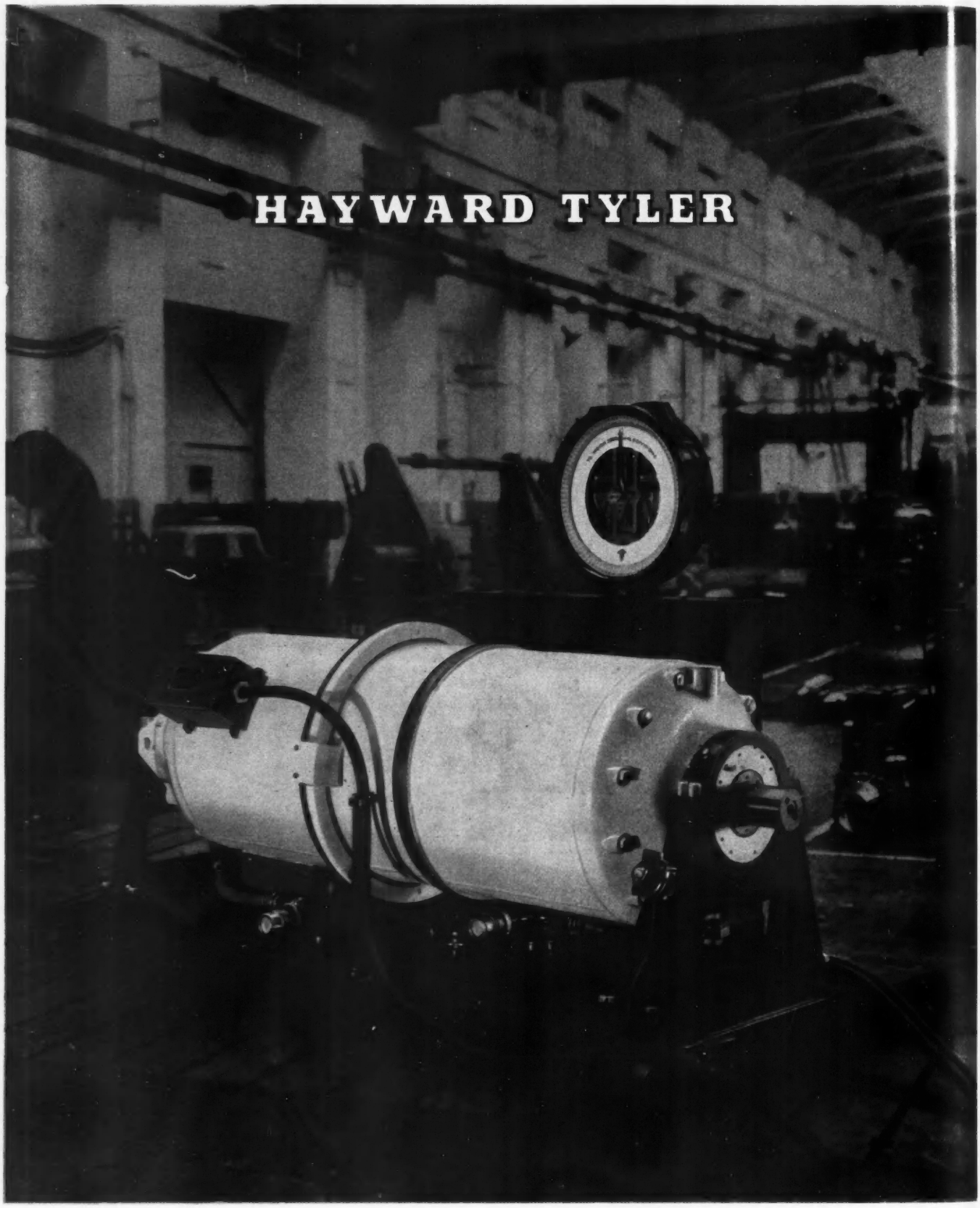

Here is a Hayward Tyler 1,000 H.P. Electromersible liquid-filled motor operating at 3,300 volts as a swinging frame dynamometer. Coupled to a pump this type of motor offers many advantages, for instance, as a totally enclosed boiler feed or circulator unit, a glandless pipe line booster, or a vertical submersible mine dewatering pump.

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THE ENGINEER

JUNE 17, 1955

Opening of Mach 3 Supersonic Wind Tunnel

THE first medium-size supersonic wind tunnel to be operated privately in this country was opened last Monday at the Armstrong-Whitworth guided missile plant at Whitley by Lord Brabazon of Tara. The tunnel has a Mach number range of 0·3 to 3·0 and can operate with stagnation pressures from 0·2 atmosphere to 1·5 atmospheres absolute, and in certain cases to 2·8 atmospheres. It has a working section of 19in by 14·5in and the Reynolds number range is from 1×10^6 per foot to 6×10^6 per foot at all Mach numbers above 1·6. The tunnel is of the continuous closed circuit layout equipped with two centrifugal compressors which can be operated in parallel or in series and driven by a single electric motor with a continuous rating of 7700 h.p. and a two-hour rating of 10,000 h.p. The decision to build the tunnel was taken by the company in 1950 but although a delivery promise was obtained for all major components and equipment for December, 1952, in several cases these dates were not realised and its completion was consequently delayed. It has cost about £200,000, which is a particularly low figure for a tunnel of this size and scope. The cost of running the tunnel is in fact stated to be lower than that obtained on any comparable tunnel in the world. At atmospheric stagnation pressure and a Mach number of 1·9 the mass flow is 1·6 tons per minute and at this speed the cost of moving the air past the model is 11d. per ton; the full power costs about 10s. a minute for electricity alone. A jet-driven induction tunnel, it was explained, cost £150 per hour per jet engine. The Whitley site was chosen because of the proximity of the River Sowe, the whole summer flow of which is required to cool the working fluid. The temperature rise, however, does not exceed 7 deg. Cent. The most modern instrumentation and recording gear is installed.

Export of Internal Combustion Engines

AT the annual general meeting of the British Internal Combustion Engine Manufacturers' Association, held on June 10th, a short survey of the export situation for 1954–55 was given. This shows that the serious decline in export sales of the previous year has been halted and that there have been certain upward trends, particularly with regard to marine auxiliary engines, and sales to Argentina, Iran and the Soviet Union. The value of exports for 1954 at £26,461,107 was an increase of about £1,000,000 over 1953, while the total horsepower at 1,489,335 represented an increase of 25·8 per cent. The first quarter of 1955, it is noted, indicates the continuation of the expansion of exports, particularly in the Middle East, following the easing of political tension and the introduction of development plans. The exporter, the survey records, continues to face foreign competition and lack of purchasing power, and also the trend towards the expansion of local internal combustion engine industries. A survey of this policy of self sufficiency and the activity of foreign competitors has been put in hand by the Association. In India and Pakistan the United Kingdom regained the lead lost to Western Germany in 1953, and the survey records that exports to the Argentine were the highest since 1952, exports to Iran increased by 127·3 per cent, and that the Netherlands was one of the most valuable markets outside the Commonwealth. It is also noted that exports have increased to Russia and Eastern Germany, while business with Brazil has been lost to Western Germany, a change which is attributed to the success of bilateral policy followed by Germany. The reasons for the unsatisfactory position of exports to Spain are mentioned in the survey and also the effect of Japanese competition in Thailand, where the value of exports has fallen by more than 50 per cent. Western Germany is mentioned as taking first place among our competitors with exports reaching a total of £13,700,000, other countries in order of priority being Switzerland, Denmark, Sweden, France, Italy, Netherlands, Belgium, and Japan. The survey remarks that the market position is reasonably encouraging, since the demand for internal combustion engines should increase as the backward areas develop, with the acquisition of new wealth.

Launch of the "Reina Del Mar"

ON Tuesday of last week, a new passenger and cargo liner for the Pacific Steam Navigation Company was launched from the Belfast yard of Harland and Wolff, Ltd., and named "Reina del Mar" by Mrs. Bowes, the wife of the managing director of the shipping company. On completion the ship will join the "Reina del Pacifico" in the owning company's service from Great Britain, France and Spain to Bermuda, the Bahamas, Cuba, Jamaica, then through the Panama Canal and down the West Coast of South America to Chile. The ship has a length overall of about 600ft, a length between perpendiculars of 560ft, a breadth moulded of 78ft, a depth moulded to "C" deck of 44ft and a gross tonnage of approximately 19,350. There is provision for three classes of passengers, including 201 first-class passengers accommodated in single and two-berth cabins on "C" and "D" decks; 218 cabin-class passengers in single, two, three and four-berth rooms, and accommodation for 343 tourist passengers in single, two, three, four and six-berth cabins on "A" and "B" decks. Extensive public rooms are provided and both the public rooms and the passenger accommodation are air conditioned, while additional comfort is available in rough weather by equipping the ship with Denny-Brown stabilisers. Ten watertight bulkheads give the necessary standard of subdivision and there are four complete steel decks and five holds for the carriage of cargo. The ship is propelled by a two-shaft arrangement of Parsons double-reduction geared turbines, which develop a service power of 17,000 s.h.p. at 112 revolutions of the propeller. Steam at 525 lb per square inch gauge and 825 deg. Fah. is supplied by two water-tube boilers, built by the shipbuilders to the designs of Babcock and Wilcox, Ltd. Two Cochran auxiliary boilers provide steam for port use, and to meet the demands for electric power for the various ship's services and auxiliary machinery there are two 1000kW turbine-driven generators arranged to run in parallel, and three 500kW diesel-driven generators.

Coal Research

THE annual report of the British Coal Utilisation Research Association, recently published, was able to record a steadily increasing membership with an income some £10,000 above that of its 1953 income of £308,000. The report notes also that the number of contacts with member firms is now running at 500 per annum. A main feature of the Association's work is concerned with the efficient utilisation of small, high-ash coal. Study has continued of the performance of boilers fired by mechanical stokers, the aim being to combine high efficiency with elimination of smoke and reduced grit emission. The programme involving the use of a coking stoker, which follows that with a chain-grate stoker, is continuing. Work has also been continued on the development of a slagging cyclone type of combustor for coal-fired gas turbines. Satisfactory performance with some coals is now in sight, and attention is being turned to the study of coals with a wider range of ash properties and to deposit-forming tendencies. Another major problem with which the Association is concerned is that of deposits and corrosion. In view of the growing use of pulverised coal at power stations, the report notes that work has been concerned mainly with combustion gases from this method of firing and a 50 lb per hour pulverised fuel furnace has been constructed for semi-scale studies under controlled conditions. Attention has also been given to coals with high chlorine contents, and it has been shown that the presence of hydrochloric acid—which could arise from these coals—accelerates corrosion at temperatures below the water dewpoint; these temperatures may occur at heat exchange surfaces during lighting up, banking or at low burning rates. This result may also be significant in relation to atmospheric pollution. During the past year operational research has been carried out on the performance of the free-standing open fire with restricted throat in ordinary homes; it has been shown that although a fuel saving, in comparison with ordinary grates, of 50 per cent or more is possible, in practice the observed saving was 21 per cent, some of the potential fuel saving being taken to provide increased comfort. Although the best hope of reducing smoke from domestic appliances lies ultimately in the use of smokeless fuels, fundamental research on the disengagement of volatiles from coal has been continued. The importance of research on the chemical and physical nature of coal is also referred to in the report. Work is now being extended to include an investigation of mineral matter in coal, with particular reference to deposition and corrosion resulting from the volatilisation of certain of the mineral constituents. Initial difficulties in the technique of X-ray examination of mineral matter have been largely overcome, and quantitative determinations of the carbonate minerals in thirty coals have been completed.

Development of Nuclear Power Plant

EIGHT British firms are co-operating in the formation of a company which is to concentrate on the research, design and construction work associated with nuclear power stations. The new company, which has been registered with an authorised capital of £1,000,000 is entitled The Nuclear Power Plant Co., Ltd., and its registered office is at Heaton Works, Newcastle upon Tyne, the design headquarters being at Booths Hall, Knutsford, Cheshire. The firms which are associated in this company are C. A. Parsons and Co., Ltd., A. Reyrolle and Co., Ltd., Head, Wrightson and Co., Ltd., Sir Robert McAlpine and Sons, Ltd., Whessoe, Ltd., Strachan and Henshaw, Ltd., Alex. Findlay and Co., Ltd., and Clarke, Chapman and Co., Ltd. All these firms have either had close association with the United Kingdom Atomic Energy Authority in the design of the Calder Hall atomic power station, or in experimental reactors for Harwell. The directors of The Nuclear Power Plant Co., Ltd., are Sir Claude Gibb, F.R.S. (president and chairman), Dr. A. T. Bowden, Mr. R. E. McAlpine, Mr. Richard Miles, Mr. H. H. Mullens, Mr. A. J. Sayers, and Sir John Wrightson, Bt. The Parolle Electrical Plant Co., Ltd., which has been associated with the United Kingdom Atomic Energy Authority in the design and construction of the Calder Hall project, will co-ordinate the activities of the eight co-operating firms in design and construction. It will also be responsible for site services.

Vertical Boiler Locomotives

By R. A. S. ABBOTT*

No. IV—(*Continued from page* 801, *June* 10*th*)

The study of the history of the industrial locomotive is a fascinating subject, quite outside the scope of ordinary railway and locomotive literature, and one which offers a wide field for research. For many years the writer has made the industrial and light locomotives with vertical boilers his special interest, and as no previous history of this type of locomotive has ever been published it is hoped that this excursion into a little explored by-way of locomotive engineering will prove welcome to both the engineer and historian.

Wilkinson of Wigan

IN 1881, William Wilkinson, of the Holmhouse Foundry, Wigan, patented a somewhat remarkable locomotive designed for tramway operation and with two main objects in view—first, to get rid of the exhaust steam without the expense of a condenser and, secondly, to make every part of the machine easily accessible. The boilers were vertical with "Field" tubes, and of 3ft 6in diameter, and made in several sizes from 5ft 1in to 7ft high. These boilers had a cast iron superheating vessel fixed in the firebox, and the exhaust steam first passed into two receivers, one on each side of the boiler, and then passed into the superheater in the firebox before escaping up the chimney. This method of getting rid of the steam nuisance in the public streets was not very successful, and so in 1886 Wilkinson patented a roof condenser as an accessory.

The engine was of the vertical launch design, made in various sizes with cylinders 6in diameter by 7in stroke; 6½in diameter by 10in stroke; 7½in diameter by 11in stroke, and 7½in diameter by 12in stroke, driving by means of a pinion on the crankshaft, a spur wheel on one axle, the two axles being coupled by rods. The gear ratio was 2 or 2½ to 1. Wheelbases varied from 5ft 6in to 5ft 8in, and weights from 5¾ to 9 tons. Overall measurements were: 11ft to 12ft long, 5ft 6in to 6ft 8in wide, and about 9ft high.

These locomotives created a very favourable impression among tramway engineers, and Messrs. Wilkinson supplied sixty-three of them (Fig. 24) to the following systems:—Birmingham and Aston; Brighton District; Dublin Southern District; Giant's Causeway, Portrush and Bush Valley; Huddersfield Corporation; Manchester, Bury, Rochdale and Oldham Company; Nottingham and District; South Staffordshire, and Wigan. The demand for these locomotives outstripped the capacity of the patentee's works, which were never very large, and, indeed, the boilers for some of the locomotives built there were supplied by Hough and Sons, Newtown Boiler Works, Wigan, so accordingly licences were granted to Thomas Green and Sons, Leeds; Black, Hawthorn and Co., Gateshead, and to Beyer Peacock and Co., Ltd., Manchester. The design, however, failed to compete successfully with the Kitson tram locomotive and after some 204 had been built the manufacture of them ceased in 1889.

When working on routes with steeply graded sections, the steam tram locomotive was often at a serious disadvantage in wet weather with greasy rails, for in the early days there were no statutory stopping places, and if any wayfarer signalled the demand to stop the signal had to be obeyed even if on a steep incline. On attempting to restart the locomotive would in all probability skid and race its wheels, only to be held up at once by the automatic brake which acted above a certain speed. This would perhaps happen several times before the locomotive got going again. The Wilkinson locomotives, being geared, were generally good starters, and their designer was probably the first to attempt to work steep gradients of 1 in 11½, 1 in 12 and 1 in 13 by steam power, but with a view to obtaining a more even torque and improving the hill-climbing powers. Wilkinson designed and built the unusual locomotive shown in Fig. 26. In this locomotive the two-cylinder vertical engine was placed at the rear of the frame and the drive to the rear axle was by a worm, the worm being of Siemens steel. The worm wheel ran in an oil bath, there being special thrust bearings provided for the crankshaft to absorb the heavy end thrust caused by starting and on the over-run with steam shut off. The gear ratio was 7½ to 1. It was predicted by contemporary engineers that the use of a worm drive would cause the wheels to lock when the throttle was closed, but Wilkinson reported that in practice this locomotive coasted quite freely. The complete engine could be removed for overhaul in two hours by releasing six bolts. The axles were coupled by rods and at 8 m.p.h. the piston speed was 436ft per minute, while a speed of 16 m.p.h. could be attained.

The second unusual factor in the design was the boiler, which was a combination of the horizontal and vertical element, with the vertical predominating; its construction will be clearly understood from the drawing. The height from foundation ring to top was 6ft 2in; distance from front tube plate to back plate, inside, 3ft 5in; diameter of horizontal portion, inside, 3ft 9in; length of horizontal tubes, 12in, with reverse curve to allow for expansion and contraction. The inside firebox was 2ft 1in long by 2ft 7in wide at bottom and 2ft 9½in at top, by 3ft high, and had a series of "Field" tubes suspended from the crown. The working pressure was 50 lb per square inch, and the boiler had an evaporative efficiency of 9·7 lb of water per 1 lb coke, with feed water at 62 deg. Fah.

Other dimensions were: coupled wheels, 3ft 2in; wheelbase, 6ft; overall length, 12ft 8in; overall height to top of chimney, 10ft 9in. All the above dimensions, except the tubes and wheels, should be regarded as approximate only, having been scaled from the original drawings on a scale of ¾in to 1ft.

The air-cooled condenser, placed low down at the front, had tubes with between 200 and 300 square feet of cooling area, and the air for combustion passed through these tubes on its way to the closed ashpan. It will be noticed that these condenser tubes, like those in the horizontal part of the boiler, had a reverse curve to allow for expansion and contraction. All steam not condensed passed into a superheater in the smokebox, the superheater tubes being exactly coincident with the boiler tubes. Under certain conditions of working, it was found that there was such an amount of expansion that the condenser condensed the greater portion of the steam and little was left to provide a sufficient draught for the fire; and to counteract this the locomotive was fitted with a variable blast pipe so that the nozzle could be restricted, when necessary, to maintain the blast. The date of this interesting locomotive is not known with any certainty, but it had been built and run on trials before 1885.

Savile Street Foundry Locomotive

The late Dr. Whitcomb, in his *History of the Steam Tram*, records that the Savile

* Member, Newcomen Society; Member, Industrial Locomotive Society.

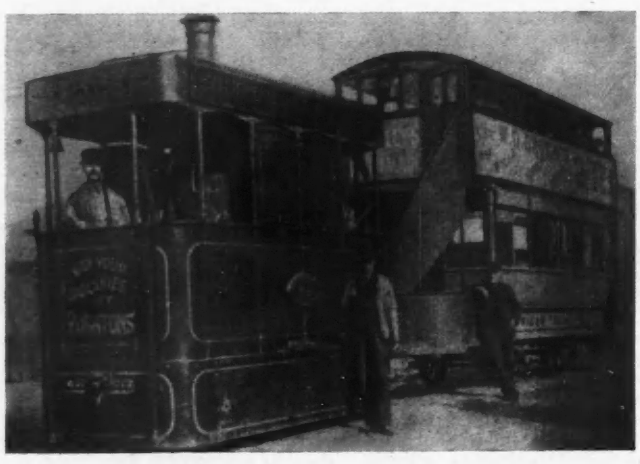


Fig. 24—Wilkinson tram locomotive, built by the patentee at Wigan for Wigan Tramways Company, Ltd., 1886

Fig. 25—Wilkinson tram locomotive, built by Black, Hawthorn and Co., Gateshead

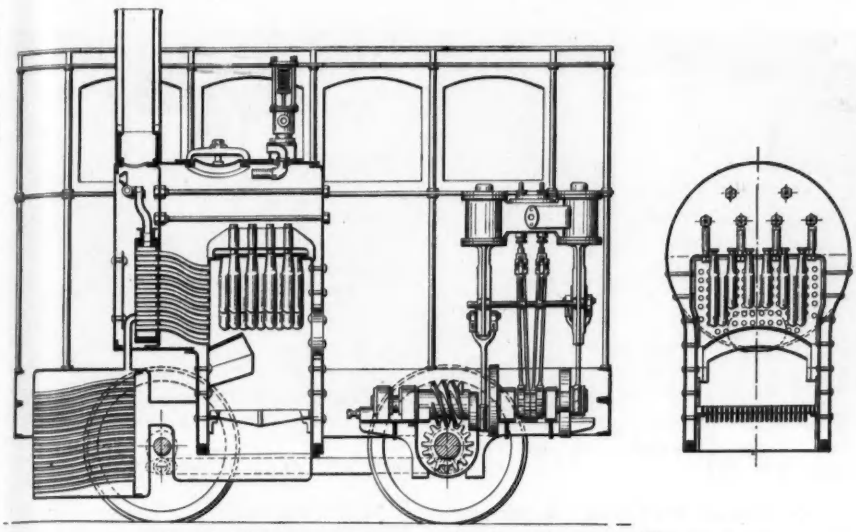


Fig. 26—Wilkinson tram locomotive with worm drive, circa 1885

Street Foundry, Sheffield, patented a compound tramway locomotive with a vertical boiler, horizontal cylinders and an air condenser under the roof. The high-pressure cylinder was 8in in diameter and the low-pressure cylinder is said to have been 21in in diameter, but if this latter dimension is correct the ratio was most unusual, being about 1 to 7 instead of the normal 1 to 2 or so. The date of construction would be about 1881, and after trials at Sheffield it was transferred to Burnley in 1882.

Wilkinson Locomotives Under Licence

As mentioned earlier, three firms took up the manufacture of the Wilkinson tramway locomotive under licence, the first of these being Thomas Green and Sons, Leeds, who supplied thirty-eight between 1882 and 1884 to the following tramways : Bradford, Bradford and Shelf, Leeds, Coventry and District, Manchester, Bury, Rochdale and Oldham Company, and the South Staffordshire. An excellent drawing showing the side elevation of one of these Green locomotives appeared in *The Locomotive* for 1923, page 181. The next firm was Black, Hawthorn and Co., Gateshead, which between 1883 and 1889 built thirty-two Wilkinson locomotives for Alford and Sutton, Gateshead and District, Huddersfield, Manchester, Bury, Rochdale and Oldham Company, North Shields and Tynemouth District (Fig. 25).

It will be convenient to mention here that Black, Hawthorn and Co. may have built other vertical boiler locomotives besides those of Wilkinson design, for in the *Machinery Market* for December, 1890, a contractor's locomotive of vertical boiler design was advertised for sale, and described as having been built by Black, Hawthorn and Co. It had outside cylinders, 6in diameter, with a stroke of 12in, a boiler 6ft high by 3ft diameter, and was suitable for a rail gauge of 3ft.

The third firm to build Wilkinson locomotives, Beyer, Peacock and Co., Ltd., of Manchester, supplied seventy-one between 1883 and 1886 (Fig. 27). These worked on the following systems : North Staffordshire, South Staffordshire, Coventry and District, Manchester, Bury, Rochdale and Oldham Company.

Slee Locomotive

In a recent book *Narrow Gauge Rails in Mid-Wales* the author, J. I. C. Boyd, mentions a vertical boiler locomotive supplied to the 2ft 3in gauge Hafan and Talybont Tramway. It is said to have been built by Slee and Co., of Earlestown, in 1897, and to have been fitted with a four-cylinder engine and an all-over cab.

Bedford Locomotives

The Bedford Engineering Company primarily built steam cranes, but during the first decade or so of the present century it was producing small vertical boiler locomotives that were virtually steam cranes without the jib. The locomotive illustrated by Fig. 28 was built for an Indian railway of 1ft 6in gauge about the year 1910, but these locomotives could be supplied for any gauge up to 4ft 8½in. The framing was of mild steel, mounted on steel-tyred wheels with volute springs, each axle having a steel spur wheel, both of which were in mesh with a large spur wheel on the countershaft ; this latter was driven by a pinion on the crankshaft. A two-cylinder horizontal engine with disc cranks had link reversing gear, while the boiler, which was of steel with water tubes, had a working pressure of 130 lb per square inch. A former employee, now deceased, stated that the firm built a number of these locomotives, but was unable to say whether any were for use in Great Britain ; it has been suggested that several went to an Indian colliery company and presumably the locomotive illustrated was one of these.

While it seems certain that only a few were built, the design was offered in three sizes as follows :—

Cylinders, diameter and stroke, inches ...	4½ × 6½	5 × 6½	6 × 8
Approximate speed on level, m.p.h. ...	8	9	10
Tonnage hauled on level	25	40	60
Tonnage hauled on incline of 1 in 30 ...	5	7	11
Approximate weight, tons	4	4½	5½
Price	£275	£325	£375

Cox

About the period 1919–1921 the firm of Cox and Co., marine engineers, of Falmouth, built a vertical boiler locomotive from Sara and Burgess drawings for the Falmouth Docks and Engineering Company.

Sentinel

The most widely known make of modern geared locomotives with vertical boilers is the varied range produced by the Sentinel Wagon Works, Ltd., of Shrewsbury (now Sentinel (Shrewsbury), Ltd.), during the last twenty-six years or so and their undoubted success is largely due to the enterprise of this firm.

The constructional details of the engines and boilers of these locomotives will be familiar to most readers, while the various designs of locomotive have nearly all been fully illustrated and described in *The Locomotive* at the time of their introduction, and it is not therefore the intention of the writer to recapitulate here particulars that are already easily accessible. See *The Locomotive* for 1926, pages 8–10 ; 1927, pages 281 and 282 ; 1929, pages 142–4 ; 1930, pages 183, 229, 291 and 401 ; 1932, page 63. The firm's latest designs were illustrated and described in THE ENGINEER as recently as May 6, 1955, pages 628–9, and May 1, 1953, pages 643–4.

There are, however, two designs of Sentinel which appear to have received little or no attention in the technical press, and these are the 80 h.p. " convertible type contractors' locomotive," and the special 100 h.p. 8-ton " B.E." locomotive standardised for 2ft gauge only. The convertible contractors' locomotive was designed to be readily adaptable for any of the three gauges of 24in, 30in and 1m respectively and was supplied in two sizes of 6 tons and 8·5 tons in working order ; it is illustrated by Fig. 29. The standard vertical water-tube boiler, designed for a working pressure of

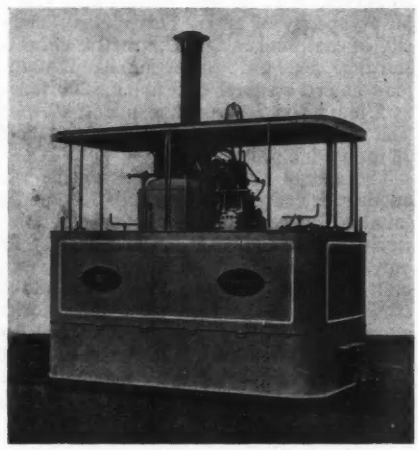


Fig. 27—Wilkinson tram locomotive by Beyer, Peacock and Co., for South Staffordshire Tramways Company, 1885

230 lb per square inch, had a superheater, which raised the steam temperature to about 700 deg. Fah., and the fittings included main stop valve, blower valve, feed water injector, and the usual gauges. As can be seen from the illustration, the vertical engine occupied the front end of the chassis and was of the standard two-cylinder double-acting design, with poppet valves operated from camshafts by pushrods and having five different cut-off positions. Transmission to the axles was by roller chains and the axleboxes were located by means of radius rods, which also served to tension the chains.

The frame, built up of mild steel plates connected by cross stays and gusset plates, had holes drilled for the reception of axles and wheels to suit any of the three gauges referred to above. A cylindrical water tank occupied the centre of the frame and carried a saddle type sand box. The brakes were hand-operated, but, in addition, the well-known Sentinel system of utilising the steam engine for braking was incorporated. This consists of drawing in atmospheric air and subjecting it to great compression in the cylinders against a release valve controlled by a foot pedal.

The normal overall height of these locomotives was 8ft 11½in, but for very restricted working conditions a modified design could be supplied with the driver's footplate

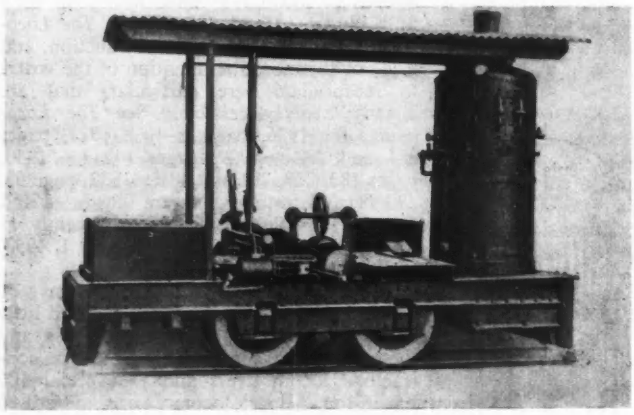


Fig. 28—Locomotive by Bedford Engineering Company, circa 1910

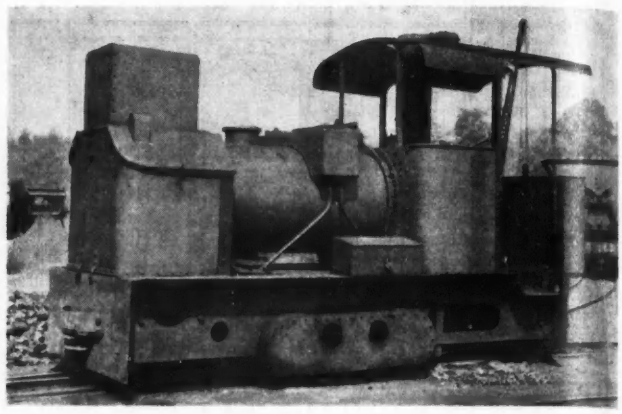


Fig. 29—" Convertible " 80 h.p. Sentinel locomotive

arranged partly inside the frame, so reducing the total height to only 5ft 2in. The following are the leading dimensions and particulars : cylinders, diameter and stroke, 6¾in by 9in ; engine speed, 500 r.p.m.; wheel diameter, 1ft 8in ; wheel base, 3ft 5in ; length over couplings, 12ft 11¾in ; maximum width, 5ft ; capacity of tanks, 175 gallons ; capacity of coal bunker, 2 cwt ; tractive effort at starting, 5000 lb ; at 6 m.p.h., 2810 lb ; load hauled on level at 5 m.p.h., 200 tons ; at 5 m.p.h. on 2 per cent gradient, 40 tons. The average coal consumption was about 18 lb. per b.h.p. hour.

The special 100 h.p. "B.E." engine was another design of narrow-gauge locomotive suitable for both contractors or plantation work, but standardised for a gauge of 2ft only. These locomotives (Fig. 30) were built up on steel plate frames with suitable cross bars and steel plate headstocks, strongly braced, gusseted and riveted together, with plain bushed axleboxes mounted on laminated steel springs, the axles with disc wheels being located by adjustable radius rods. The vertical water-tube boiler and controls were mounted behind the rear axle, with tank and bunker positioned in the centre, while the engine, being mounted at the front end of the frames, drove by roller chains on each side, to a countershaft directly in the centre of the frame under the water tank ; there being a separate chain from this shaft to each axle inside the frames. Controls were grouped to one side of the boiler, but the throttle and brake were operated from either side. The cab was normally of open canopy form, as shown in the illustration.

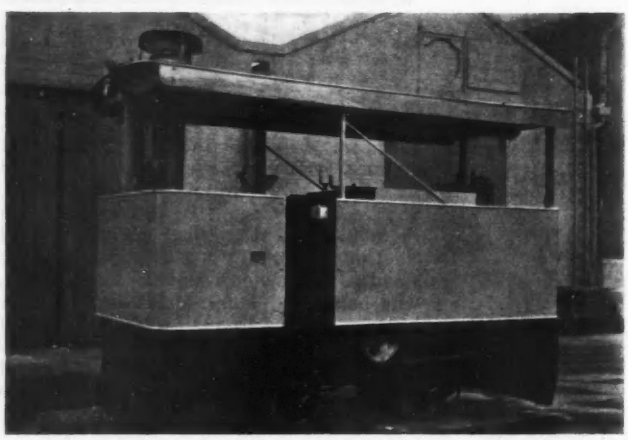


Fig. 30—100 h.p. "B.E." Sentinel locomotive for 2ft gauge

The standard two-cylinder double-acting poppet valve vertical engine was capable of developing 100 b.h.p. at 400 r.p.m., with a boiler pressure of 275 lb per square inch, and could be run up to 600 r.p.m. Two cut-off positions were provided, giving a 75 per cent and 40 per cent cut-off in both directions. To enable the engine to work at its most economical speeds while performing the bulk of the work for which the locomotive was supplied, a standardised range of chain sprockets was offered, as shown in the following table :—

Countershaft sprocket	Crankshaft pinion		
	13 teeth	15 teeth	17 teeth
29 teeth	9·78 m.p.h.	11·29 m.p.h.	Not used
21 teeth	13·51 m.p.h.	15·59 m.p.h.	17·69 m.p.h.

The above speeds were based on a crankshaft speed of 500 r.p.m., and in all cases the countershaft pinions had eleven teeth and the axle sprockets fifteen teeth. Pitch of chains, engine to countershaft, 1¼in pitch ; countershaft to axles, 2½in pitch. Both brake and sanding gear were hand operated. Other dimensions were : length over headstocks, 12ft 11½in ; length over buffers (block, pin and link type), 14ft ; width overall, 5ft 11¾in ; wheel base, 4ft 5in ; wheel diameter, 1ft 8in ; boiler working pressure, 275 lb per square inch; heating surface of tubes, 29·5 square feet ; firebox, 23 square feet ; superheater, 12·5 square feet ; grate area, 3·97 square feet.

Boiler feed was by a ram pump driven off the timing gears, with one live steam injector. With a tank capacity of 200 gallons and a bunker holding 7 cwt of coal, the loaded weight of these locomotives was 8 tons and maximum tractive effort 4480 lb.

These small locomotives of the two classes described above were designed to be handled by one man, no difficulty being experienced in combining both stoking and driving. Further, as these locomotives burnt coal or coke, even of inferior grade, they showed marked economy over small internal combustion locomotives of similar power. It was claimed that only in the case of very low-powered locomotives being required could the internal combustion locomotive of suitable size give better results.

Besides the building of complete locomotives the Sentinel Company has specialised in the supply of boilers and engine units for the rebuilding of orthodox locomotives whose boilers and cylinders have become worn beyond economical repair. A large number of such units have been supplied, and although the appearance of some of these rebuilds is not exactly pleasing to the eye, their resulting efficiency is beyond dispute.

(To be concluded)

Survey of Manufacturing Activity in Australia

THE Department of National Development of the Australian Commonwealth Government has just released a further survey of manufacturing activity. The latest publication, dated May 16, 1955, is one of a series undertaken by the Division of Industrial Development at six-monthly intervals, the purpose being to ascertain quickly and accurately the current level of activity in key manufacturing industries in Australia.

It is based on interviews with selected industrialists and others in all States of the Commonwealth, the sample being chosen to cover those firms and industries which are likely to show early evidence of significant trends and changing conditions. By this means, it is aimed to provide a barometer of the manufacturing climate for the guidance both of Commonwealth Government departments and businessmen planning programmes for production, sales or investment.

Industries chosen for survey employ somewhat less than half the total number of persons in manufacturing industries. The coverage within the samples taken ranges from 100 per cent in industries concentrated in the hands of a few companies to 20 per cent or less in industries consisting of a large number of small firms. As a general rule, a representative sample covering about 50 per cent of each industry was attempted.

The survey is in two sections—a General Report and a series of Reports on Selected Industries. The general report is a concise account of the conclusions drawn from the survey. It also highlights key facts, and will be appreciated by those with Australian interests as an authoritative and succinct treatment affording the means for readily making an accurate assessment of the health of the manufacturing sector of the Australian economy.

The Reports on Selected Industries section embodies the more important industry studies upon which the general report is based and includes much up-to-date and detailed information.

In the light of the demand experienced for earlier surveys in this series copies have been reproduced in London, and may be obtained by application to The Senior Representative, Department of National Development, Australia House, Strand, London, W.C.2.

Normally copies of the general report only will be supplied but a relatively small number of copies of the full survey is available for distribution in appropriate cases.

Design of Surface-Water Sewers by Tables

By L. B. ESCRITT, A.M.I.C.E.

MUCH office time can be saved if a rapid system can be used when designing large numbers of surface-water sewers as, for example, in connection with the sewerage of extensive estates. It is suggested that the system described here is at least more rapid than most in current use.

The method is based on the equation of a formula for rainfall run-off with a formula for pipe discharge, so that diameter of sewer required can be found directly, or with little trial and error, without even the necessity of ascertaining the flow. As the formula that results from the equation involves fractional powers, simplified logarithmic tables are prepared so that calculations may be made merely by addition and subtraction.

The formula for run-off selected is :—

$$Q=\frac{357Ap}{t^{0.625}}$$

where :—

Q=run-off in cubic feet per minute.
Ap=impervious area in acres.
t=time of concentration in minutes.

This is made up from the Lloyd-Davies formula with the value of

$$\frac{5\cdot9}{t^{0.625}}$$

for R, the intensity of rainfall in inches per hour. This value of R is selected in preference to the Ministry of Health standard curve, for the following strong reasons :—

The standard curve was evolved as a temporary expedient, pending the acquisition of more adequate data.

The standard curve is accurate only over a limited range—less than that to which it is normally applied—and cannot be extrapolated without gross inaccuracy.

The Ministry of Health formula, containing as it does plus signs and constants which are varied according to the value of t, is inconvenient mathematically.

The formula substituted in place of the Ministry of Health formula is accurate for storms of all duration liable to be involved in normal sewerage calculations, i.e. from five minutes to twenty-four hours.

For flow in pipes, Crimp and Bruges' formula has been selected. Any other formula of the same kind, e.g. Manning's

Impervious area

Ap	S	Ap	S	Ap	S	Ap	S	Ap	S	Ap	S
0·1	1553	3·6	3109	10·5	3574	36	4109	105	4574	360	5109
0·2	1854	3·7	3121	11·0	3594	37	4121	110	4594	370	5121
0·3	2030	3·8	3133	11·5	3614	38	4133	115	4614	380	5133
0·4	2155	3·9	3144	12·0	3632	39	4144	120	4632	390	5144
0·5	2252	4·0	3155	12·5	3650	40	4155	125	4650	400	5155
0·6	2331	4·2	3176	13·0	3667	42	4176	130	4667	420	5176
0·7	2398	4·4	3196	13·5	3638	44	4196	135	4684	440	5196
0·8	2456	4·6	3216	14·0	3699	46	4216	140	4699	460	5216
0·9	2507	4·8	3234	14·5	3714	48	4234	145	4714	480	5234
1·0	2553	5·0	3252	15·0	3729	50	4252	150	4729	500	5252
1·1	2594	5·2	3269	15·5	3743	52	4269	155	4743	520	5269
1·2	2632	5·4	3285	16·0	3757	54	4285	160	4757	540	5285
1·3	2667	5·6	3301	16·5	3770	56	4301	165	4770	560	5301
1·4	2699	5·8	3316	17·0	3783	58	4316	170	4783	580	5316
1·5	2729	6·0	3331	17·5	3796	60	4331	175	4796	600	5331
1·6	2757	6·2	3345	18·0	3808	62	4345	180	4808	620	5345
1·7	2783	6·4	3369	18·5	3820	64	4369	185	4820	640	5359
1·8	2808	6·6	3373	19·0	3832	66	4373	190	4832	660	5373
1·9	2832	6·8	3386	19·5	3843	68	4386	195	4843	680	5385
2·0	2854	7·0	3398	20·0	3854	70	4398	200	4854	700	5398
2·1	2875	7·2	3410	21·0	3875	72	4410	210	4875	720	5410
2·2	2895	7·4	3422	22·0	3895	74	4422	220	4895	740	5422
2·3	2915	7·6	3434	23·0	3915	76	4434	230	4915	760	5434
2·4	2933	7·8	3445	24·0	3933	78	4445	240	4933	780	5445
2·5	2951	8·0	3456	25·0	3951	80	4456	250	4951	800	5456
2·6	2968	8·2	3467	26·0	3968	82	4467	260	4968	820	5467
2·7	2984	8·4	3477	27·0	3984	84	4477	270	4984	840	5477
2·8	3000	8·6	3487	28·0	4000	86	4487	280	5000	860	5487
2·9	3015	8·8	3497	29·0	4015	88	4497	290	5015	880	5497
3·0	3030	9·0	3507	30·0	4030	90	4507	300	5030	900	5507
3·1	3044	9·2	3517	31·0	4044	92	4517	310	5044	920	5517
3·2	3058	9·4	3526	32·0	4058	94	4526	320	5058	940	5526
3·3	3072	9·6	3535	33·0	4072	96	4535	330	5072	960	5535
3·4	3084	9·8	3544	34·0	4084	98	4544	340	5084	980	5544
3·5	3097	10·0	3553	35·0	4097	100	4553	350	5097	1000	5553

Time of concentration

t	T	t	T
0 to 5	0437	35	0965
5·5	0462	36	0972
6·0	0486	37	0980
6·5	0508	38	0987
7·0	0528	39	0994
7·5	0547	40	1001
8·0	0564	42	1014
8·5	0580	44	1027
9·0	0596	46	1039
9·5	0611	48	1050
10·0	0625	50	1062
11·0	0650	52	1072
12·0	0674	54	1082
13·0	0696	56	1092
14·0	0716	58	1102
15·0	0735	60	1111
16·0	0752	62	1120
17·0	0769	64	1129
18·0	0784	66	1137
19·0	0799	68	1145
20·0	0813	70	1153
21·0	0826	75	1172
22·0	0832	80	1189
23·0	0851	85	1205
24·0	0862	90	1221
25·0	0874	95	1236
26·0	0884	100	1250
27·0	0894	110	1275
28·0	0904	120	1299
29·0	0914	130	1321
30·0	0923	140	1341
31·0	0932	150	1360
32·0	0940	160	1377
33·0	0949	170	1394
34·0	0957	180	1409

Gradient

1 in :	U	1 in :	U	1 in :	U	1 in :	U	1 in :	U
6	0389	38	0790	100	1000	320	1252	880	1472
7	0422	39	0795	105	1010	330	1260	900	1477
8	0451	40	0801	110	1020	340	1266	920	1482
9	0477	42	0811	115	1030	350	1272	940	1486
10	0500	44	0822	120	1039	360	1278	960	1491
11	0521	46	0831	125	1048	370	1284	980	1495
12	0539	48	0840	130	1057	380	1290	1000	1500
13	0557	50	0850	135	1065	390	1295	1050	1510
14	0573	52	0858	140	1073	400	1301	1100	1520
15	0588	54	0866	145	1081	420	1311	1150	1530
16	0602	56	0874	150	1088	440	1321	1200	1539
17	0615	58	0881	155	1095	460	1331	1250	1548
18	0627	60	0889	160	1102	480	1340	1300	1557
19	0639	62	0896	165	1108	500	1349	1350	1565
20	0650	64	0903	170	1115	520	1358	1400	1573
21	0661	66	0910	175	1122	540	1366	1450	1580
22	0671	68	0916	180	1127	560	1374	1500	1588
23	0681	70	0922	185	1133	580	1382	1550	1595
24	0690	72	0928	190	1139	600	1389	1600	1602
25	0699	74	0935	195	1145	620	1396	1650	1609
26	0707	76	0940	200	1150	640	1403	1700	1615
27	0715	78	0946	210	1161	660	1410	1750	1621
28	0723	80	0951	220	1171	680	1416	1800	1627
29	0731	82	0956	230	1181	700	1422	1850	1633
30	0738	84	0962	240	1190	720	1429	1900	1639
31	0745	86	0967	250	1199	740	1435	1950	1645
32	0753	88	0972	260	1207	760	1440	2000	1650
33	0760	90	0977	270	1215	780	1446	—	—
34	0765	92	0982	280	1223	800	1451	—	—
35	0772	94	0986	290	1231	820	1457	—	—
36	0778	96	0991	300	1239	840	1462	—	—
37	0784	98	0995	310	1245	860	1467	—	—

Diameter

V	D (inches)	W
2104	4	3151
2506	6	3269
3045	9	3386
3379	12	3469
3637	15	3534
3848	18	3587
4027	21	3631
4181	24	3670
4318	27	3704
4440	30	3735
4550	33	3762
4651	36	3787
4744	39	3811
4829	42	3832
4909	45	3852
4984	48	3871
5054	51	3888
5120	54	3905
5183	57	3921
5242	60	3935
5299	63	3949
5353	66	3963
5408	69	3976
5454	72	3988
5547	78	4012
5632	84	4032
5712	90	4053
5787	96	4071
5857	102	4089
5923	108	4106
6032	120	4132
—	—	—

Increment time

t_1	X
0·1	0000
0·2	0301
0·3	0477
0·4	0602
0·5	0699
0·6	0778
0·7	0845
0·8	0903
0·9	0954
1·0	1000
1·1	1041
1·2	1079
1·3	1114
1·4	1146
1·5	1176
1·6	1204
1·7	1230
1·8	1255
1·9	1279
2·0	1301
2·1	1322
2·2	1342
2·3	1361
2·4	1380
2·5	1398
2·6	1415
2·7	1431
2·8	1447
2·9	1462
3·0	1477
3·1	1491
3·2	1505

Increment length

L	Y	L	Y	L	Y	L	Y	L	Y	L	Y	L	Y	L	Y
10	2000	100	3000	190	3279	280	3447	370	3568	460	3663	550	3740	640	3806
20	2301	110	3041	200	3301	290	3462	380	3580	470	3672	560	3748	650	3813
30	2477	120	3079	210	3322	300	3477	390	3591	480	3681	570	3756	660	3819
40	2602	130	3114	220	3342	310	3491	400	3602	490	3690	580	3763	670	3826
50	2699	140	3146	230	3361	320	3505	410	3613	500	3699	590	3770	680	3832
60	2778	150	3176	240	3380	330	3518	420	3623	510	3708	600	3778	690	3839
70	2845	160	3204	250	3398	340	3531	430	3633	520	3716	610	3785	700	3845
80	2903	170	3230	260	3415	350	3544	440	3643	530	3724	620	3792	710	3851
90	2954	180	3255	270	3431	360	3556	450	3653	540	3732	630	3799	720	3857

formula or Barnes' formula, could be substituted, but in this case fresh tables would have to be made to allow for the different values of constants and indices. Crimp and Bruges' formula reads :—

$$Q=\frac{3\cdot072D^{\frac{8}{3}}}{I^{\frac{1}{2}}}$$

where :—

Q=cubic feet per minute.
D=diameter of sewer in inches.
I=length divided by fall.

Equating the modified Lloyd-Davies formula with Crimp and Bruges' formula, we get :—

$$D^{\frac{8}{3}}=\frac{357ApI^{\frac{1}{2}}}{t^{\frac{8}{3}}}.$$

The method of using the tables to solve this formula is as follows :—

$S+U-T=V$. Then, according to the value of Ap read off the "logarithm" S. Add to this the "logarithm" for gradient U and deduct the "logarithm" for time of concentration T. This gives the value V from which the diameter of sewer can be found by reference to the appropriate table.

When calculating the lengths of long main sewers, trial and error is often unavoidable because the value of t is not known until the diameter of sewer has been found. But in estate drainage, where calculations are made from manhole to manhole, the additional length of sewer is usually in the region of 300ft, and the increment of t seldom exceeds two minutes and averages about one minute. So if in the calculation the time of concentration is taken as being one minute more than the time of concentration of the sewerage system upstream of the length of sewer in question, the error will usually be so small that no adjustment of diameter will have to be made.

Having found diameter of sewer, find the actual increment time of concentration so as to determine the time of concentration for the next calculation for the length of sewer downstream. This is found by the formula :

$$t_1=\frac{LI^{\frac{1}{2}}}{563D^{\frac{8}{3}}}$$

where L is increment length of sewer in feet : or, $U+Y-W=X$.

Then the value of t_1 is found from the table as follows. Add the "logarithm" for the gradient U to the "logarithm" for length Y and deduct the "logarithm" for diameter W. This gives X which is the "logarithm" for t_1. It should be noted that the "logarithms" in the table include the constants and powers of the values in the formulas and certain arbitrary values which are brought into eliminate decimals and minus signs : they are not the true logarithms of the numbers concerned.

Example Calculation

Total impervious area draining to the point in question	2·1 acres
Gradient of sewer	1 in 84
Length of sewer	275ft
Time of concentration upstream	5·27 minutes
For Ap=2·1	S=2875
For gradient=1 in 84	U=0962
	3837
For t=5·27+1, say 6	T=0486
	V=3351 ∴ D=12in

Next, find increment time of concentration:

For gradient=1 in 84	U=0962
For L=275	Y=3439
	4401
For D=12	W=3469
	X=0932 ∴ t_1=a little less than 0·9 minute

It is now seen that the true time of concentration is a little less than 6·17, which correction does not alter the diameter of sewer calculated.

Plastics Exhibition

Some details are given below of some of the latest developments in the moulding and press tools which were made available for demonstration either at the recent Plastics Exhibition or at the maker's works. They include very large preplasticising injection moulding machines of up to 120 oz capacity, vacuum form moulding equipment, continuous weighing equipment for moulding machines, large moulding presses and vacuum coating machines.

ONE of the more apparent developments in injection moulding machines noticeable at the British Plastics Exhibition was the continuing trend towards completely automatic units and units of greatly increased size. One machine in this latter category is that illustrated in Fig. 1. This unit, which could only be demonstrated at the maker's works, is made by R. H. Windsor, Ltd., Leatherhead Road, Chessington, Surrey. It has a moulding capacity of up to 120 oz per shot, with the denser plastics, and has an overall weight of 60 tons. The base of the machine is 25ft by 5ft 2in and the size of the mould plates 5ft 10in by 5ft 2in. The size which moulding machines of this capacity assume can be appreciated by the loading indicated in the specification. With a pressure on the plasticised material of 13,000 lb per square inch, the total pressure on the injection plunger is 157,000 lb and the locking force is 1150 tons. The stroke of the injection plunger is 16in and it takes only three seconds for the complete injection stroke injecting at 400 cubic inches per minute.

The machine has a plasticising capacity of 500 lb per hour, the maximum moulding volume per shot being 200 cubic inches, which is equivalent to 120 oz of polystyrene. The heating load in the preplasticiser is 46kW and the maximum pump horsepower of moulding machine is about 125 h.p.

This company was also able to demonstrate on its stand an 88 cubic inch preplasticising machine which it has recently designed and introduced. It has exactly twice the capacity of the company's earlier units, the capacity moulded per shot being 88 cubic inches, or 52 oz of polystyrene. The machine has a complete moulding cycle of less than one minute. It has moulding plates 34in by 38in, occupies a floor space 24ft by 4·75ft, and employs approximately 40 pump horsepower.

Another company which has developed a 120 oz injection moulding machine is the Projectile and Engineering Company, Ltd., Acre Street, London, S.W.8. A unit was available for demonstration at the company's works, but the specification of this machine has not yet been published. This machine is fitted with the company's "In-line" preplasticising unit, for which it claims special advantages over existing preplasticising units. The company explained that with most of these units, including the one which it first demonstrated in 1953, introduced considerable mechanical complication and other difficulties associated with scavenging and the changing of material. The company regards the "In-line" unit as being considerably more simple and flexible in operation.

The principle of the "In-line" preplasticiser is as follows :—

It comprises a long heating chamber which is fed through a normal hopper feed by a plunger operating at a maximum pressure of 10,000 lb per square inch.

In order to increase the efficiency of heating, the chamber has been made longer than usual. With normal heating chambers there are length limitations due to the excessive pressure drop in the heating chamber and the difficulty of controlling pressure at the nozzle. With a preplasticiser this difficulty is non-existent as the plunger pumps the material into an auxiliary chamber and, therefore, pressure drop and pressure fluctuations are unimportant.

The nozzle in the heating chamber is designed as a plunger. The material is squirted through the centre hole of the nozzle into the injection transfer pot, which is coaxial with the heating chamber and is fixed to a hydraulically operated crosshead. Injection into the cavity takes place with the whole heating chamber acting as a plunger and moving forward against the stationary injection transfer pot. After the necessary holding-on period a further charge of material is pumped from the heating chamber into the injection transfer chamber, moving the whole heating chamber assembly back to its original position.

The developments in moulding equipment exhibited by Alfred Herbert, Ltd., Coventry, included a Herbert/Reed-Prentice "10D" 8 oz moulding machine fitted with an automatic weighing attachment. It is shown in Fig. 2 and a close-up of the attachment is reproduced in Fig. 3. The weighing machine can complete sixteen complete weighing and depositing cycles in one minute, and observe an accuracy of half of 1 per cent of the weight required. The principle of operation depends on a simple, but very fine and accurately made, weighing beam. Material from the hopper passes through bulk and fine feed openings to separate vibrating trays and again through separate nozzles to the weighing pan. As each dose approaches completion the bulk feed nozzle is closed and the make-weight added through the fine feed nozzle only. These operations are initiated by the movement of the weighing beam and electric contacts. A solenoid-operated cam and clutch mechanism automatically tips the weigh pan on completion of each cycle.

The development of moulding machines for

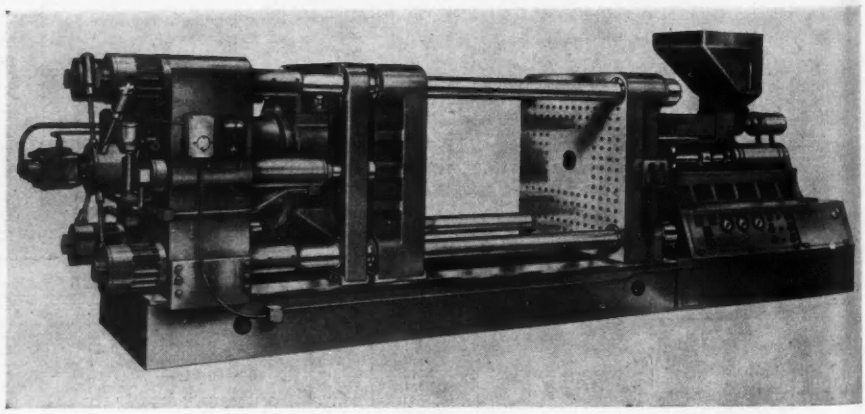


Fig. 1—120 oz injection moulding machine

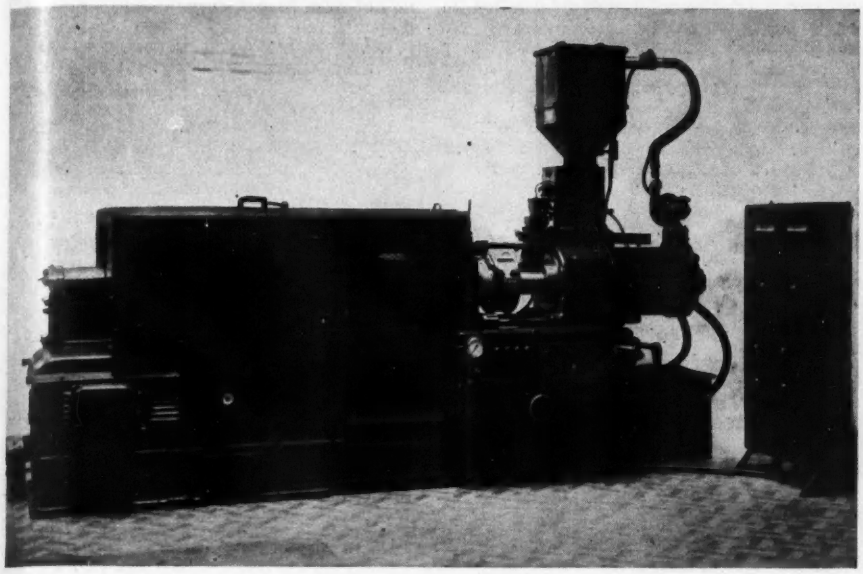


Fig. 2—8 oz moulding machine with automatic weighing attachment

moulding by vacuum forming from thermoplastic sheets has extended the field of moulding to the economical production of articles considered too expensive to produce by the conventional moulding methods. Such articles of large area, such as refrigerator, motor and aircraft parts, outside advertising and window displays, can now be produced. Mould costs are also much lower with this process as moulds can be made from such materials as cement, plaster, wood, cast resin or light alloys.

The Pulsometer vacuum forming machine shown on the stand of Alfred Herbert, Ltd., is made with single or twin platens to handle a sheet up to 26in by 36in square. The dimensions of the mould chamber are adjustable and the internal depth can also be adjusted to accommodate a maximum draw of 6in.

A toggle fastener permits feeding direct from rolls of sheet material. A blanket design heater has a consumption of 9·6kW per hour and is equipped with polished aluminium reflectors.

The machine employs a water-cooled pump with a swept volume of 60 cubic feet per minute. It is able to recover from the evacuation of one mould chamber in approximately fifteen seconds, permitting a thirty-second cycle on the thinner grades of sheet.

In our illustration (Fig. 5) of a twin platen machine the heat carrier and the blanket heater are shown in the centre of the machine and the controls are centralised at the right-hand end.

Another development on the stand of this company, shown in Fig. 4, is the largest low-pressure moulding press in this country. It is a 250-ton machine and is made by T. H. and J. Daniels, of Stroud.

Vacuum forming and vacuum coating machines were the principal exhibits of W. Edwards and Co. (London), Ltd. This company has now started manufacture of the "Formvac" series in association with the Swiss firm of Hydro-Chemie, Ltd., in order to provide a complete range of machines. A twin-table machine was exhibited with an effective moulding area on each table of 40in by 60in and a maximum depth of draw for female moulds of 22in. The depth of draw for male moulds is reduced to 14in or perhaps somewhat greater, the limitation here being the sagging of the heated sheet just before moulding, which cannot be exactly estimated.

The "Formvac" machines operate completely automatically after placing the plastic sheet in position, the throwing of a single switch causing the sheet to be heated and the mould to be made, cooled and stripped ready for removal by the operator. The time occupied by all operations, heating, cooling, blow-off pressure, stripping, can be preset to suit all conditions of plastic sheet thickness, depth of draw, and type of moulds. A heater is fitted, which, it is claimed, softens thermo-plastic sheet two to three times faster than any other. It is arranged so that full heat is only given while over the work, only quarter power being used during idling time. Up to 30 per cent of the electricity consumption is saved with lengthened life of the heater. Per-

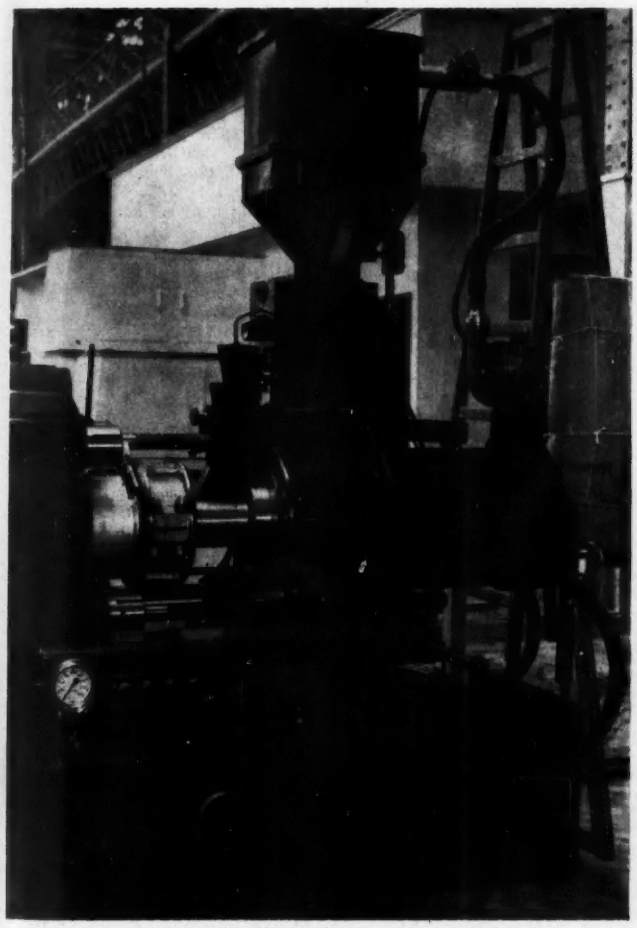


Fig. 3—Close-up of automatic weighing attachment

Fig. 4—250-ton down stroke, low-pressure moulding machine

fectly uniform heat distribution is ensured by full heat only when the heater is over the work and allows the best mechanical properties to be given to the formed article by prevention of the overheating of the rear of the sheet.

Vacuum Coating.—Vacuum coating is the preferred process for metal finishing many plastic moulded articles, and the company exhibited a medium-sized coating unit for quantity production. In conjunction with simple dip lacquering techniques all polishing operations can be eliminated for the production of a mirror finish of metalised mouldings, beautiful colour effects being readily obtainable.

One model shown had a 36in diameter work chamber, 36in long. It is fitted with a rotary work-holder suitable for a variety of plastic mouldings from costume jewellery and "back coating" transparent badges, insignia, &c., the so-called three-dimensional effect, to lacquered base reflectors for torches and motor car headlamps. A new pumping system incorporating very high-speed "Speedivac" booster

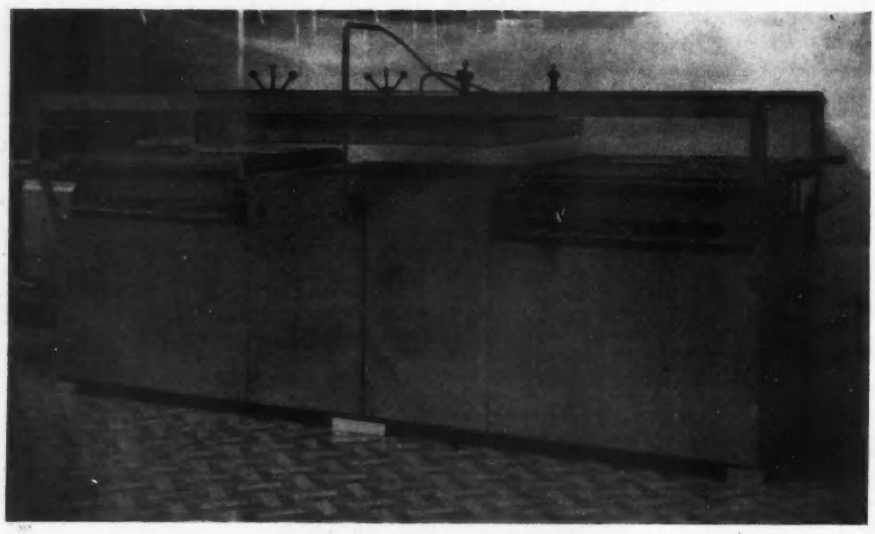


Fig. 5—Vacuum form moulding machine

pumps gives repeatable chamber exhaustion times of the order of twelve minutes to a pressure of 5mm by 10^{-4}mm of mercury or below. The lowest possible pressure is of great importance for first-class coating and the booster makes its attainment possible even when vacuum-impairing bases are being coated. Rapid production cycles are given by the outstanding pumping capacity, which is further improved by the fitting of an air scavenge rotary mechanical pump, thus permitting the abolition of the chemical desiccant moisture trap.

Continuous Roll Vacuum Coating Plant.—Not so well known as the vacuum coating described is the deposition of thin films of metals on a continuous roll or strip of material. An Edwards machine was exhibited which provides for coating up to 5in. wide and a 6in spool diameter. Deposition of zinc or aluminium can be carried out on condenser paper or plastics sheet.

The pumping system comprises a "Speedivac" model 9B1 booster pump, designed to deal with high degassing rates in the industrial pressure range of 10^{-3} to 1·0mm of mercury where such degassing is prevalent from the strip material handled, which in turn is backed by a "Speedivac" air ballast pump capable of pumping any condensable vapours likely to be evolved by the rolled material without contamination of the pump oil and hence loss of vacuum performance. A by-pass valve and baffle isolation valve above the vapour pump are incorporated in order to allow the chamber to be initially evacuated by the rotary pump; gauging for process control and performance checking is provided.

The horizontal vacuum chamber is 2ft in diameter and 2ft long, with a hinged door. Work changing is quite an easy matter because the work holder can be partially withdrawn on runners. Included in the roller system is an intermediate rubber-covered driving roller running at constant speed, driven by an external electric motor via a vacuum seal, ensuring that the linear speed is constant irrespective of the material spool diameter.

The electrically heated and controlled vapour sources are varied according to the metal being evaporated, taking care of different volatilities, evaporative temperatures and possibility of attack on evaporative arrangements. Very high coating speeds of several hundred feet per minute are possible with zinc when a relatively simple evaporative source is possible. A thermo-couple and meter are fitted to show the zinc vapour stream temperature and an ohmmeter to measure the electrical resistance of the deposited zinc film; the metallised surface is passed over two insulated rollers connected to the meter circuit.

Aluminium is the preferred metal for most coating applications because of its lustre, appearance and resistance to oxidation. The development of continuous coating of this metal at the rate of 100ft per minute has now been successfully completed.

Material for metallisation generally requires a preliminary treatment under vacuum to evaporate absorbed moisture solvents, &c., which would otherwise evolve during the coating process and which affect the coated surface or increase the time spent on the coating cycle, and suitable equipment was exhibited. It is desirable to carry out this operation in a separate degassing plant so that maximum output may be obtained from the roll coating chamber and subsequent work carried out therein.

Other important developments apart from those dealing with moulding machines could be noted on the stand of T.I. Plastics, Ltd., Creda Works, Blythe Bridge, Staffs. Tubing rod and mouldings were among the exhibits there made from polytetrafluoroethylene (P.T.F.E.), which has the I.C.I. trade name of "Fluon."

Although generally classed as a thermoplastic resin, P.T.F.E. does not melt and flow, as do conventional thermoplastics, such as P.V.C. or polythene. Special techniques are therefore necessary for the fabrication of P.T.F.E., in general consisting of a cold-forming operation followed by sintering at temperatures upwards of 330 deg. Cent. P.T.F.E. is generally regarded as being non-toxic, but care should be taken to avoid inhaling vapour evolved at high temperatures or fine dust. The serviceable temperature range is of the order of −100 deg. to 250 deg. Cent. P.T.F.E. has an extremely low coefficient of friction and also has a non-adhesive surface. P.T.F.E. tubing can be threaded or tapped with conventional equipment.

The ultimate tensile strength of P.T.F.E. is 1500 lb to 2500 lb per square inch, and an elongation of from 50 to 200 per cent; the electrical properties are similar to those of polythene. P.T.F.E. has been used continuously at 500 deg. Fah.; decomposition occurs at about 400/450 deg. Cent., but it is non-inflammable. It possesses practical universal chemical inertness, is light stable and its surface is not wetted.

Adoption of the Unified Screw Thread by British Industry

THE conclusion that the unified screw thread would ultimately supersede the Whitworth thread was formally recorded by a special conference in London on May 23rd, when representatives of many branches of the engineering industries, the Service Departments, and the nationalised industries met under the chairmanship of Mr. H. A. R. Binney, director of the British Standards Institution, to review how far the unified thread has, in fact, been adopted in this country. The conference was called in response to many inquiries which the B.S.I. had received from industrial producers and users of engineering equipment, from Government departments and others concerned to know how far and how fast the change-over from the Whitworth thread had progressed in the seven years since the signing of the "Declaration of Accord" between America, Britain and Canada, under which the three countries agreed to accept the unified thread.

It was recalled in the opening discussion at the conference that in the years immediately following the signing of the accord, several British Standards were developed for unified bolts and nuts, screwing tackle and other details necessary for the implementation of the agreement. Reviewing progress from that point, the manufacturers of bolts and nuts said that in the early stages they had been unable to meet all the demands for unified bolts and nuts, but recently the position had improved. The draft standard for black bolts and nuts in the "normal" series would soon be issued, and they now foresaw no serious difficulty in meeting any future demands likely to be made upon them. Representatives from the motor, aircraft, oil and chemical industries and from the Atomic Energy Authority all said that they had adopted the unified screw thread, and confirmed that by and large availability now presented no problem. They were unanimous in stating that the change-over had not been nearly as inconvenient as they had thought it would be, and were of the opinion that the difficulties involved could easily be exaggerated.

The discussion brought out that one of the major difficulties to be faced related not so much to the change from Whitworth to unified bolts and nuts, but to the fact that tapped holes were employed in such a great variety of engineering equipment produced in many separate industries which included several comparatively small firms.

The conference felt that the three key factors in the further progress of the change-over were:

(*a*) Large organisations, such as the nationalised industries, which placed many large orders for equipment, and which, by specifying unified screw threads, could help to influence and speed the change-over;

(*b*) The stockist, who was responsible for supplying small orders to a great number of small firms, and

(*c*) The many small manufacturers, who produce miscellaneous industrial equipment with tapped holes.

The indications all showed that the rate of the change-over had been considerably faster than might have been expected some four or five years ago; but, having regard to the advantages to be achieved by working to a single screw-thread system, particularly one which there is every reason to believe will receive increasing support in the Commonwealth and other overseas markets, it was generally agreed to be desirable that the tempo of the change-over should be increased. The B.S.I. was asked to take such steps as were appropriate to secure wider publicity for this objective. The conference will meet again in about six months' time to review the progress then made.

Standard Class "9" Locomotives fitted with Franco-Crosti Boilers

Ten standard British Railways class "9" heavy duty freight locomotives are being built with Franco-Crosti boilers. This type of boiler is designed to increase locomotive efficiency by passing the gases normally exhausted directly through the chimney through a bank of tubes to preheat the feed water.

WHEN the designs of the British Railways class "9" standard heavy freight locomotives were being prepared it was decided to equip ten of the locomotives with Franco-Crosti boilers in order to carry out comprehensive trials with the system. It will be remembered that this standard 2–10–0, two-cylinder locomotive was designed initially under the direction of Mr. R. A. Riddles, railway executive member for mechanical and electrical engineering, and subsequently under the direction of Mr. R. C. Bond, chief mechanical engineer of the British Transport Commission. The work of designing the ten special locomotives was carried out in conjunction with the Societa per Azioni Locomotive a Vapore Franco-Crosti of Milan, and in close consultation with Dott. Ing. P. Crosti.

The leading particulars of the locomotives are given in the table below.

Leading Particulars of Freight Locomotive with Franco-Crosti Boiler.

Cylinders (2), diameter and stroke ...	20in by 28in
Wheels, coupled diameter	5ft
Wheels, tender, diameter	3ft 3½in
Wheels, pony truck, diameter	3ft
Wheelbase, coupled	21ft 8in
Wheelbase, engine	30ft 2in
Wheelbase, engine and tender	55ft 11in
Heating surface :	
Main boiler :	
Tubes	1,274 square feet
Firebox	158 square feet
Total evaporative	1,432 square feet
Superheater	411 square feet
Preheater :	
Tubes	1,021 square feet
Exhaust steam jacket	57 square feet
Grate area	40·2 square feet
Boiler pressure	250 lb per square inch
Tractive effort	39,667 lb
Weight of engine in working order ...	90 tons 4 cwt
Weight of engine and tender in working order	141 tons 9 cwt

The general layout of the locomotives was made with as few modifications as possible from the orthodox class "9," some parts of which, in accordance with the practice followed on the standard locomotives, were designed at Derby, Doncaster and Swindon. In retaining as many features as possible identical on the standard class "9" and the Franco-Crosti locomotives, the aim was to render possible conversion either way in the light of actual experience. Of the ten locomotives being built at Crewe, several have now been completed.

In the orthodox steam locomotive the firebox gases, after leaving the tubes, are ejected to the atmosphere through the chimney, carrying away with them a substantial amount of heat. In the Franco-Crosti system the normal chimney on the front smokebox is closed, and the gases pass through a bank of tubes in a secondary drum, or drums, before being ejected from the final chimney.

The secondary drum is used to preheat the feed water supplied by the feed pump or injectors, so that the water enters the boiler proper at a temperature only slightly less than that of the water already in the boiler. In this way a large amount of heat is utilised which would otherwise be wasted. Some heat is also extracted from the exhaust steam and this may be done in two ways :

(1) By means of a jacket encircling part of the preheater drum or drums, exhaust steam fed to this jacket imparts some of its heat to the relatively cold water fed by the feed pump or injector.

(2) Exhaust steam may also be used in an exhaust steam injector.

The water circuit is thus as follows : the cold feed from the tender is forced through a clack valve on the remote end of the preheater drum, either directly by means of a feed pump, or else after mixing with steam in an injector. The water in the preheater, which is at approximately boiler pressure, is displaced by fresh feed entering and moves up towards the near, or hot end, whence it passes by way of pipes to the main boiler clack valves. The main boiler is of the normal design, having no special details, except that for a given power output it can generally be made a good deal smaller than the boiler of the corresponding orthodox locomotive.

The principle is one of "contra-flow," whereby the hot gases and cold water flow in opposite directions through the system. This enables the maximum amount of heat to be extracted from the gases as it tends to equalise the temperature gradient between gases and water at all stages ; the coldest water being heated by the coldest gases at the remote end of the preheater and likewise the hottest water, which is that in the vicinity of the firebox, being heated by the hottest gases.

The expected economies arise not only from the heat in both the gases and the exhaust steam utilised, which would otherwise escape from the chimney, but also from the incidental increase in combustion efficiency, which should result from the less quantity of coal burned. Against these

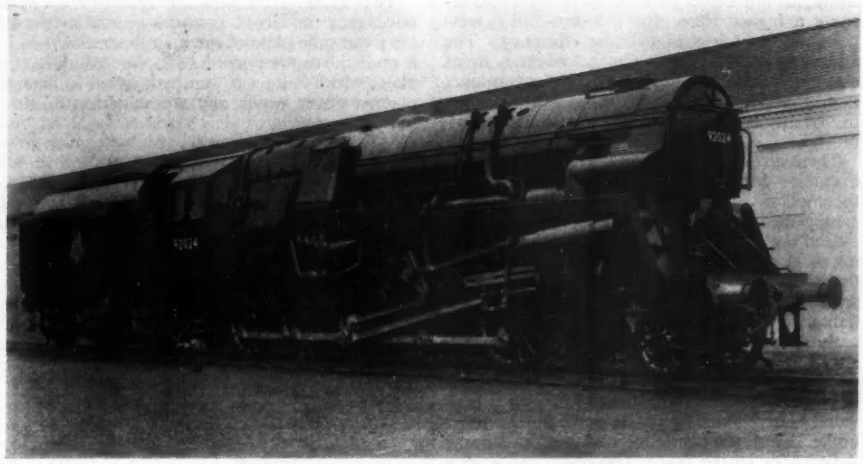
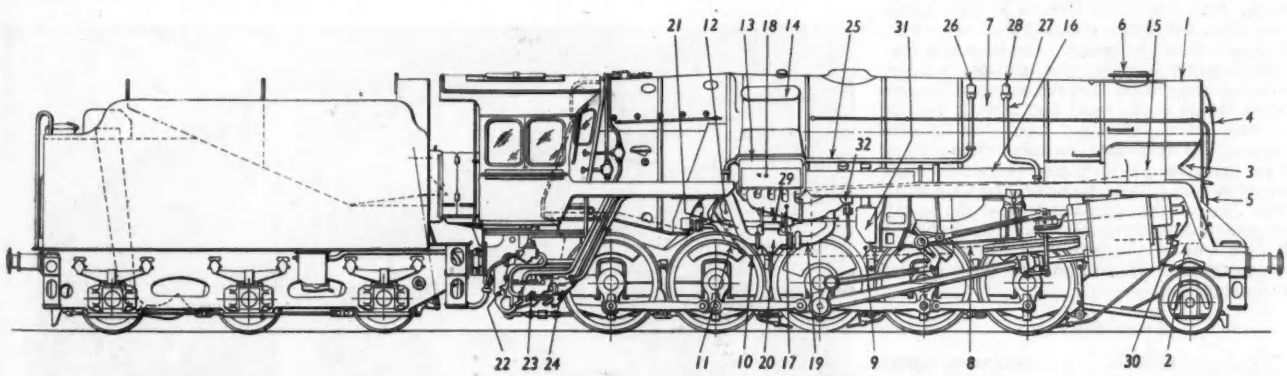


Fig. 1—Standard locomotive with Franco-Crosti boiler



1. Front smokebox.
2. Front smokebox extension.
3. Front smokebox side pocket.
4. Front smokebox large door.
5. Front smokebox small door.
6. Chimney, for lighting up only.
7. Main boiler.
8. Preheater.
9. Preheater steam jacket.
10. Final smokebox.
11. Final smokebox door.
12. Final smokebox extension.
13. Final smokebox elbow.
14. Final chimney.
15. Casing over steam and exhaust pipes.
16. Casing over exhaust pipes.
17. Manifold for blast pipe nozzles.
18. Cover for access to blast pipe nozzles.
19. Exhaust steam to grease separator.
20. Grease separator for exhaust steam injector.
21. Exhaust steam pipe to exhaust steam injector.
22. Exhaust steam injector.
23. Live steam injector.
24. Two-way valve connected to live steam injector.
25. Delivery pipe from two-way valve to main boiler.
26. Clackbox for above pipe (right-hand side only).
27. Delivery pipe from preheater to main boiler, on both sides.
28. Clackbox for above pipe, on both sides.
29. Supporting bracket for final chimney and grease separator.
30. Sandbox, leading coupled wheels, forward running, on both sides.
31. Sandbox, driving coupled wheels, forward running, on both sides.
32. Sandbox, driving coupled wheels, backward running, on both sides.

Fig. 2—Arrangement of standard class "9" locomotive with Franco-Crosti boiler

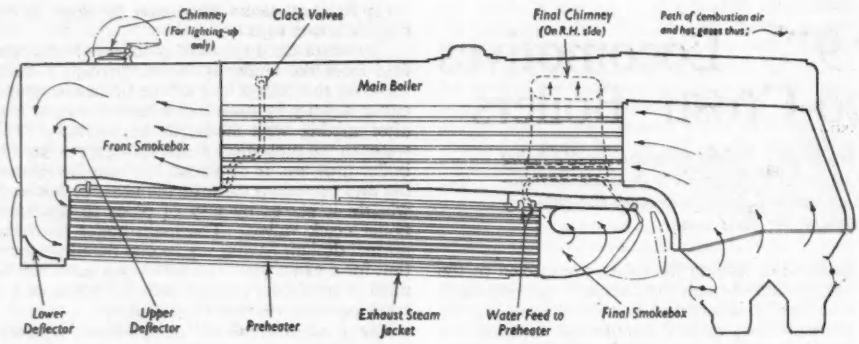


Fig. 3—Diagram of Franco-Crosti boiler as applied to a class "9" locomotive

advantages it has not been overlooked that the gases require more energy in order to pull them through both banks of tubes, tending to necessitate a higher blast pipe pressure and corresponding slight loss of cylinder efficiency. The attraction of the Franco-Crosti system is in its essential simplicity and by it all the advantages of feed water heating are obtained without the use of any additional moving part on the locomotive.

There are various ways in which the preheater drum, or drums, can be accommodated on the locomotive frame and in some Continental arrangements two drums are placed, one on each side of the boiler, with the final chimneys emerging on either side of the barrel just in front of the firebox. The direction of the gases is thus reversed at the front smokebox and thereafter they travel rearwards so as to complete a double path. With a locomotive of the size of the class "9," 2–10–0, on the British loading gauge, it was physically impossible to dispose the drums in this manner. Instead, one drum only is provided between the frames underneath the main boiler barrel, the centreline of the drum sloping downwards to the rear. The drum has a final smokebox, located just in front of the throat-plate of the main boiler, and the blast chamber and final chimney are placed on the right-hand side of the barrel, just ahead of the firebox, as shown diagrammatically in Fig. 3.

Boiler

The back-plate of the boiler proper and the disposition of the controls are identical with those of the class "9" locomotives and the ash pan and grate are also the same. The boiler is smaller in diameter, but otherwise similar in general design, having a Belpaire firebox with combustion chamber, regulator in dome, superheater, &c. The boiler shell is of high tensile steel plate, the barrel consisting of two rings, the rear ring being tapered. The front and rear barrel rings are rolled from plate of $\frac{1}{2}$in and $\frac{9}{16}$in thickness, respectively, and the outside diameters are 4ft 11$\frac{3}{4}$in at the front end and 5ft 7$\frac{1}{2}$in at the back where the barrel meets the Belpaire firebox. The drumhead smokebox tube-plate is of $\frac{3}{4}$in thickness and there are twenty-eight large flue tubes 5$\frac{1}{4}$in outside diameter, and sixty small tubes 2$\frac{3}{4}$in outside diameter; and the length between tube-plates is 16ft 5in. The firebox is 7ft 5$\frac{1}{2}$in long at the bottom with a maximum outside width of 7ft $\frac{1}{4}$in, giving a grate area of 40·2 square feet.

Front Smokebox

The front smokebox is a welded vessel rigidly attached to the front of the main boiler barrel, which rests upon main supports under the front barrel ring and is there rigidly attached to the frame. Expansion of the front smokebox is freely permitted forwards and expansion brackets carry the weight on to the front ends of the frame plates.

The gases entering the front smokebox from the boiler tubes pass to the front of the chamber and over a vertical deflector plate which is provided to trap the smokebox char. They then pass downwards into the pocket which forms the entrance to the preheater tubes, fitted with the lower deflector which is curved to lead the gases into the preheater tubes.

Two smokebox doors are fitted; the upper one, being the larger, provides general access to the front tube-plate of the main boiler. When it is open the centre portion of the vertical deflector plate, which is hinged, can be lowered to form a platform over which any accumulation of char can be swept out. The lower door is for access to the front tube-plate of the preheater, but before this can be reached it is necessary to remove the curved deflector plate. The chimney on the front smokebox is only required for lighting-up purposes and is, therefore, fitted with a door which is closed for normal running and secured by means of a central dart.

A superheater header of orthodox design is accommodated in the front smokebox and there are twenty-eight bifurcated elements 1$\frac{1}{4}$in outside diameter with the Superheater Company's design of ball end. The main steam pipes to the cylinders pass forwards to the front of the box and then downwards, passing out horizontally from the "ears" of the box through glands which allow of free expansion of the box forwards in relation to the steam pipes.

Preheater

The preheater, which is shown in Fig. 4, is essentially a welded drum 2ft 7$\frac{3}{4}$in inside diameter and containing ninety steel tubes of 2$\frac{1}{4}$in outside diameter, 19ft 3in between tube-plates. It is riveted by means of a circular flange to the front smokebox and is carried also by diaphragm plates suspended from the main boiler barrel. Elbows welded to the top of the barrel at the front and to them are connected the feed pipes to the main boiler. Clack valves on the rear end of the preheater barrel are fed by the injectors. A large manhole is provided for access to the preheater for inspection of the inner surfaces when the tubes are removed, and the cover is fitted with a safety valve set to 275 lb per square inch, to prevent the possibility of excessive pressure in the preheater.

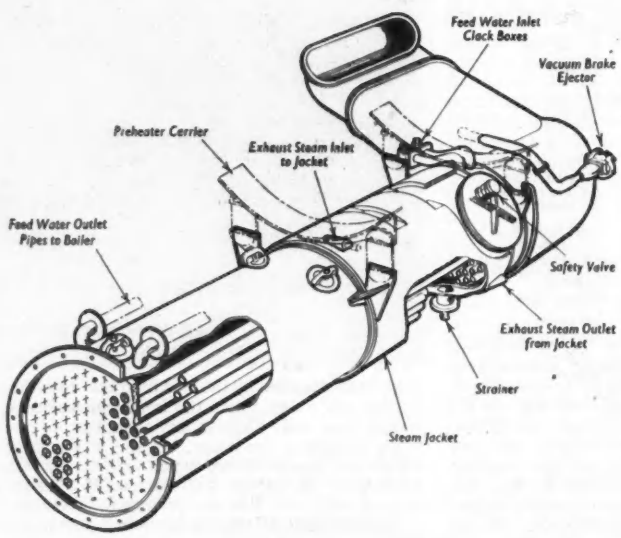


Fig. 4—Preheater of Franco-Crosti boiler

The rear portion of the preheater is enveloped in a jacket into which is passed a small quantity of exhaust steam drawn from the left-hand cylinder exhaust pipe. This steam enters at the top of the front of the jacket and is intended to impart its heat to the feed-water in the preheater and mainly be condensed. To take away any air which accumulates from the steam, outlets are

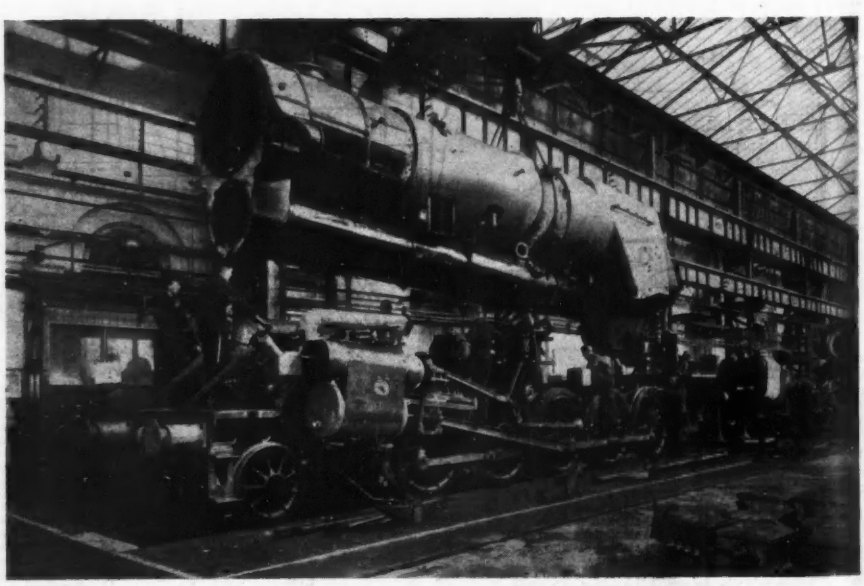


Fig. 5—Franco-Crosti boiler being fitted to locomotive at Crewe works

provided towards the bottom of the jacket, at the rear end, and these pass to the final smokebox, where the draught should be sufficient to suck out the air and promote a small circulation of the steam through the jacket. A sump provided at the bottom of the jacket is fitted with a "Spirax" steam trap to take away the condensate.

Injectors

The boiler is fed by two injectors mounted exactly as on the class "9" locomotives. The exhaust injector is of the type "K" supplied by Davies and Metcalfe, Ltd., and has 11mm cones. The live steam injector is of the B.R. standard pattern and is fitted with 10mm cones. Both injectors are mounted on the right-hand side and normally deliver water direct to the preheater, but in an emergency water can be fed directly to the boiler proper by unsealing and turning a two-way valve fitted in the live steam injector delivery pipeline. This directs the feed into a pipe running up to a separate clack valve on the front barrel ring. When water is fed to the preheater it displaces a like volume of water which passes up through two outlet pipes connected to the two normal top feed clack valves fitted to the front barrel ring of the boiler proper.

Final Smokebox

The final smokebox, of welded construction, rigidly attached to the rear end of the preheater drum, has a door at its rear end and this door is hinged from the top and secured to its asbestos-packed seating by means of dogs. A catch is provided for holding the door open for washing-out and for cleaning the inside of the smokebox. This final smokebox, illustrated in Fig. 5, has a tubular extension to the right-hand side of the locomotive leading to the blast chamber, or elbow, which houses the blast pipe

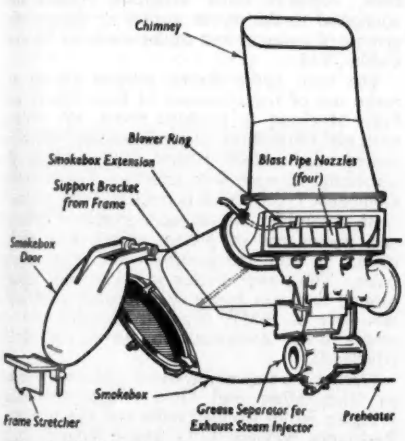


Fig. 6—Final smokebox, blast pipes and chimney

nozzles. The blast chamber is placed on the right-hand side of the locomotive so as not to interfere with the driver's view of the track ahead from the cab. The fireman's view is, however, slightly more obstructed than with normal locomotives. The "oval"-shaped chimney attached to the top of the blast chamber passes upward and is inclined towards the centre of the locomotive, being made as high as the loading gauge will permit and in such a way as to enable the exhaust to clear station awnings as far as possible. To reduce the corrosion in the final smokebox, blast chamber and chimney, the whole of the inner surface of these details is "Calorized."

The blast chamber is carried on a substantial bracket from the main frame and is provided through a sliding bearing to allow for expansion of the preheater. This bracket also carries the grease separator for the exhaust injector. The chimney is located laterally by means of a pin-jointed stay from the boiler barrel. At the base of the blast chamber is an exhaust manifold which is connected at its front end to the combined exhaust steam pipe from the cylinders. This manifold carries the four 2½in diameter blast pipe nozzles, which are mounted in a straight line so as to exhaust into the "oval" chimney. Each nozzle has a spherical mounting so that it can be adjusted to direct its steam jet correctly into the chimney. A removable plate on the outside of the blast chamber provides access to the nozzles, so that any deposit of carbon can be removed when necessary.

Exhaust steam from the cylinders, instead of passing directly into the base of the blast pipe in the front smokebox, as on a normal locomotive, is carried back in two long pipes, that on the right-hand side passing directly from the cylinders to the blast chamber and that on the left-hand side passing back and then under the boiler barrel, to join the other pipe just before entering the blast chamber.

Frames

The frames of this engine follow as closely as possible those of the standard locomotives. They consist of 1½in thick frame plates rigidly stayed by vertical and horizontal stretchers, some of which have had to be slightly modified to accommodate the preheater. As in the case of the standard engine, the frame plates are located in the planes of the centre lines of the coupled axleboxes with the hornblocks of symmetrical horseshoe form welded in.

The smokebox saddle has been eliminated and in its place there is fitted a large stretcher shaped to fit under the preheater. The front of the main boiler is carried on a saddle riveted to the barrel near the front tube-plate and supported on a tee-shaped flange welded to the top edge of the main frame plates.

Plain bearing axleboxes are employed throughout the engine. The coupled wheel axleboxes are steel castings with pressed-in horseshoe brass bearings, white metal lined and mechanically fed with oil. The hornblock and axlebox faces are lined with manganese steel.

The two outside cylinders, with a diameter of 20in and stroke of 28in, are steel castings fitted with cast iron liners to the cylinder barrel and steam chest. These cylinders are similar to those of the standard engine but with the exhaust passages arranged to connect with the exhaust steam pipes that pass back along each side of the engine to the final smokebox. The valve gear is identical to the standard engines except that the reversing shaft is positioned higher so that it may pass between the main boiler and the preheater and this necessitates a longer lifting link. The piston valves have a nominal diameter of 11in and have a maximum travel in full forward gear (78 per cent cut-off) of 7⅛in, with a steam lap of 1 1/16in and a lead of ¼in. Lubrication of the cylinders and piston valves is by atomised oil fed from a mechanical lubricator, whilst the valve gear is lubricated mainly by grease. The reversing gear consists of a screw located at the reversing shaft with the nut acting directly upon the reversing shaft arm.

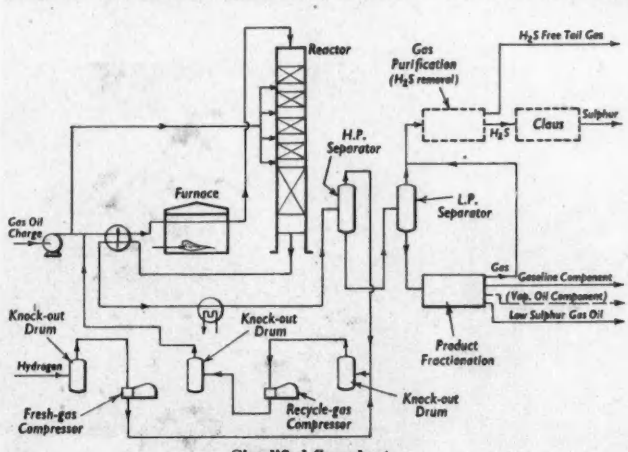
The coupled wheels are of 5ft diameter and their tyres are secured by Gibson rings. The method of balancing the reciprocating masses is the same as that used in the standard locomotives. The pony truck, with 3ft diameter wheels, is of the standard B.R. pattern. Steam sanding is provided, but owing to the presence of the preheater between the frames it has been necessary to find alternative positions for sand-boxes, in consequence of which a return has had to be made to individual sand-boxes for each feed. The leading sand-boxes are placed ahead of the cylinders and these feed the leading wheels in the forward direction. The driving wheels have both front and rear sanders and the boxes for these are mounted outside the frames, below the platform.

To permit access to the part of the platform on the right-hand side, between the cab and the blast chamber, a long step is provided below the cab side, and sunken hand-rails are fitted to the side of the cab. This enables the isolated part of the platform to be reached from the footplate when the locomotive is not in motion.

Steam brakes are provided on both engine and tender. The engine has one brake cylinder operating on the first two pairs of coupled wheels, and another on the last three. The brakes can be operated by means of a graduated steam brake valve or else in conjunction with the vacuum brake on the train.

Hydro-Desulphurisation Plant at Stanlow Refinery

EXTENSIVE laboratory and pilot plant investigations have been carried out, in recent years, at the Amsterdam laboratories of the Royal Dutch/Shell Group in an effort to develop a low-cost hydro-desulphurisation process. An analysis of the cost of the hydro-desulphurisation of oil distillates showed that a reduction in cost resulted when the amount of cycle gas was reduced. Unfortunately, the reduction of cycle gas below conventional level resulted in operating conditions under which most of the feed was no longer vaporised, but remained in the liquid state. It was revealed by research that by allowing oil to trickle over a solid catalyst in the presence of a relatively small amount of hydrogen a high degree of desulphurisation was obtained and that the activity of the catalyst was not impaired. It was also shown that this technique could be applied to a variety of base materials with various catalysts. The "trickle" technique involves low hydrogen recycle rates and a significant saving in operating and capital cost because of the smaller capacity and reduced power consumption of the hydrogen recycle compressors, and the reduction in the heat transfer area required.



Simplified flow chart

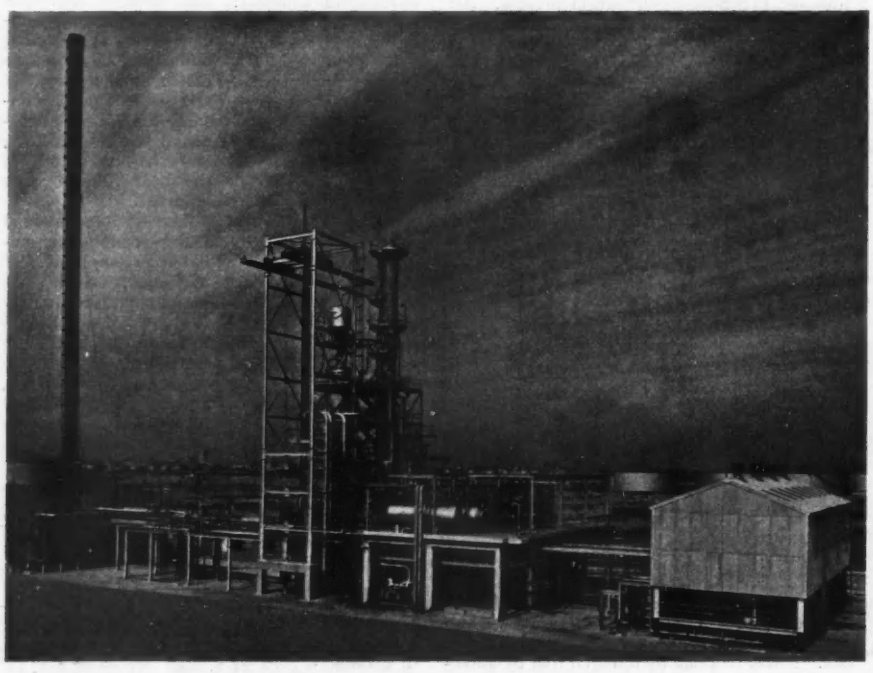
The first commercial hydro-desulphuriser employing the "trickle" technique, which has been built at the Stanlow Refinery of Shell Refining and Marketing Company, Ltd., came on stream in April last, and is shown in our illustration. The new plant, in which hydrogen converts sulphur into hydrogen sulphide, which is separated from the oil and later converted into pure sulphur, will increase the supply of high-quality fuels for diesel engines and make a certain amount of a 100 octane motor spirit component. Cobalt-molybdenum-alumina catalyst is used and was developed especially for high selectivity—that is, very little hydrogenation of aromatics even at a high degree of sulphur removal. Although able to desulphurise a variety of feed stocks the plant has been designed

mainly for the desulphurisation of light catalytic-cracked cycle oil. Operational results of the plant have exceeded design expectations and 90 per cent desulphurisation has been obtained for feed rates of 5000 and 7000 barrels per day.

Our drawing shows the flow scheme in simplified form. Separate compressors compress the hydrogen, to be consumed during hydro-sulphurisation reactions, and the hydrogen-rich recycle gas, used for catalyst protection. The latter gas is combined with about 80 per cent of the charge oil and introduced into feed product heat exchangers and the reactor charge heater, where it is raised to the reactor inlet temperature, while the remaining 20 per cent of the charge oil is fed cold to the reactor to dissipate the heat of the reaction and limit the reactor outlet temperature to a predetermined level. The products from the reactor—hydrogen light hydro-carbons, partly vaporised desulphurised cycle oil and hydrogen sulphide—exchange heat with the reactor feed and are then further cooled before being introduced into the high-pressure separator where the hydrogen-rich gas is separated. This is recycled or bled into the refinery fuel gas system after having the hydrogen sulphide removed by scrubbing with di-ethanolamine.

The liquid from the high-pressure separator is flashed in the low-pressure separator and then introduced into the fractionation section. This consists of a main fractionator and two side strippers, and here the desulphurised product is split into three fractions, while the dissolved light hydrocarbons and hydrogen sulphide are removed overhead. These overhead gases join the gases flashed off in the low-pressure separator and pass to a gas purification unit and sulphur recovery plant. When processing light catalytic-cracked cycle oil the reactor products are split into a highly aromatic heavy gasoline fraction, a 220 deg. to 260 deg. Cent. fraction, and as a main product a bottom fraction which boils above 260 deg. Cent. Reboiler heat for the side strippers is provided by a slip stream taken from the fractionator bottom stream, while a reboiler furnace supplies heat to the main column.

A total of nearly 25 metric tons of catalyst is divided over six beds in the reactor, the upper bed having superimposed a 2ft. thick layer of ceramic balls to serve as a scale catcher. At throughputs of 5500 and 7000 barrels per day the respective space velocities were 1·27 volumes/volume-hour and 1·59 volumes/volume-hour. So far operational results have shown that the 260 deg. Cent. plus fraction contained 0·3 per cent of sulphur, while the sulphur contents of the other fractions were lower than anticipated. The product distribution was as expected, 70 per cent being the 260 deg. Cent. plus fraction, 25 per cent being the 220 deg. to 260 deg. Cent. fraction, while the gasoline fraction, which had a clear research octane number of over 100, amounted to 5 per cent. The success of the injection of 20 per cent of the charge oil cold into the mixing-redistributing trays in dissipating the heat of reaction was shown by the temperature readings and no excessive rise in temperature was observed. It is considered that the performance of the first hydro-desulphuriser is satisfactory, with a 90 per cent sulphur removal when processing light catalytic cracked cycle oil at 7000 barrels per day.



Hydro-desulphurisation plant at Stanlow refinery

I.E.E. Summer Meeting in Scotland

THE summer meeting of the Institution of Electrical Engineers was held last week in Scotland. For many of the 400 members and ladies who took part it was the second visit of its kind since the war, recalling the 1949 summer meeting when the party was based on Pitlochry and saw, under construction, the North of Scotland Hydro-Electric Board's projects of Tummel Garry and Loch Sloy. Last week some of the newer and more remote of the Board's schemes were inspected, and the outward and homeward journeys provided the opportunity to revisit, after six years, the power stations, now completed, at Loch Sloy, Clunie and Pitlochry.

The meeting began on Monday, June 6th, with a civic reception in the Glasgow City Chambers by the Lord Provost and magistrates of the city. After the reception the guests were charmingly entertained at a concert by the Kirkintilloch Junior Choir, and there was dancing in the banqueting hall.

On Tuesday morning the party set out by coach for Inverness, which, for the rest of the meeting, was to serve as a centre for a series of visits to hydro-electric works and local industries. On the outward journey a stop was made during the morning at Loch Sloy power station, which is intended mainly for peak load operation, power being generated by four English Electric 32·5MW alternators, each driven by a vertical water turbine under a net head of 810ft. The water is brought from Loch Sloy to the power station on the shores of Loch Lomond by a concrete-lined tunnel through Ben Vorlich. After lunching at Fort William the party visited the 84MW Lochaber power station and works of the North British Aluminium Company, Ltd. Here water from Loch Treig and Loch Laggan drives twelve 10,000 h.p. impulse turbines, each coupled in tandem to two d.c. generators. The whole output of the station, about 450 million units per annum, is used for the production of aluminium in electrolytic cells.

From Inverness visits were made to three of the North of Scotland Hydro-Electric Board's schemes—Conon Valley, Glen Affric, and Garry-Moriston. The development of the River Conon and its tributaries involves the construction of seven dams and six power stations with an installed capacity of 107MW. The installations seen during the I.E.E. tour included Grudie Bridge power station, in which water from Loch Fannich drives two Harland vertical water turbines, each coupled to a Bruce Peebles 13·3MVA, 500 r.p.m. alternator. Similar generating sets are also to be installed at Glascarnoch power station on the shores of Loch Luichart and will use water impounded by a dam on the Glascarnoch River, about 5 miles to the north. Water from Loch Luichart will drive two English Electric 12MW sets at Luichart power station. An interesting installation at Luichart dam is the Borland "lock gate" fish lift, made by Glenfield and Kennedy, Ltd. Below Luichart a dam and power station are being built at Torr Achilty, where a head of 42·5ft to 47ft will be used to operate two Boving vertical water turbines, each coupled to a Metropolitan-Vickers 8·3MVA, 167 r.p.m. alternator. At all these stations the generated output is transformed from 11kV to 33kV for transmission by overhead line to a switching station at Beauly.

In the tour of the Glen Affric Scheme visits were made to the Mullardoch and Benevean dams and Fasnakyle power station which contains three English Electric/Harland 22MW alternators driven by vertical Francis turbines. The nearby outdoor substation, which is well-screened by trees, contains three 11/132kV transformers connected to the power station by three trefoil groups of underground cables made by Scottish Cables, Ltd.

The third hydro-electric scheme visited will make use of the resources of Glen Garry and Glen Moriston to produce about 168 million units and 120 million units, respectively. Here we visited Ceannacroc power station and the associated Cluanie dam (Mitchell Construction Company, Ltd.), which is built of Trief concrete (with a considerable saving of Portland cement) and makes use of precast interlocked facing blocks on both the upstream and downstream faces. The power station is being built underground and will house two vertical generating sets—one of 16MW (English Electric) and the other, using compensation water, of 4MW (Harland).

During the stay at Inverness visits were made to Glen Mhor and Glen Albyn distilleries, Pringle's Holm woollen mills and the works of Resistance Welders, Ltd. The company's main interest is in the manufacture of resistance and flash butt welding machines but it retains, in its general engineering, ship repair and agricultural departments, links with its earlier history, since 1872, when it was founded to manufacture agricultural implements. An associate company, Cable Belt, Ltd., was formed in 1949 to develop a new kind of conveyor belt in which the belt itself is relieved of the driving tension : the drive is provided by two continuous wire ropes acting on "V"-grooves formed at both edges of the belt, which is of reinforced rubber-cotton construction.

Two evening functions were held in Inverness. On Wednesday evening there was a civic reception by the Provost and magistrates and on Thursday there was a dinner at the Caledonian Hotel, at which the president of the Institution, Mr. J. Eccles, presided. Because of the rail strike the projected visit to Skye on Friday was cancelled. By way of compensation, shorter sight-seeing trips were arranged and members had the alternative of visiting one of the three hydro-electric schemes, mentioned above.

OIL DISCOVERY.—The D'Arcy Exploration Company has discovered oil at Edgmanton, some 6 miles from the oilfields at Eakring, Notts, the show of oil occurring at a depth of 3200ft.

25ft Vertical Boring and Turning Mill

A DOUBLE-STANDARD vertical boring and turning mill recently completed at the works of George Richards and Co., Ltd., Broadheath, Manchester, has a maximum swing of 25ft 3in, and the maximum height under the toolholders is 13ft. Its table is arranged to carry work weighing up to 90 tons, and particular attention has been paid in design to give ease and simplicity in setting and control.

As can be seen in the illustration on this page the machine has two counterbalanced vertical tool heads mounted on saddles on its cross slide. The tool bars have a down feed of 8ft and can be swivelled to any angle up to 30 deg. on either side of vertical with reference to a graduated index mechanism. A push-button-controlled 3 h.p. motor on each saddle is used for the swivelling motion.

Each tool head has sixteen feed rates from 0·007in to 0·75in per revolution for horizontal, vertical and angular motions. Each head has its own independent feed box at the opposite ends of the cross slide, and the feed rates during a machining operation need not necessarily be the same. Thus, when machining surfaces on the periphery and near the centre of large diameter work the most appropriate feed rate can be selected for each head—a useful feature particularly when cutting with carbide tools. In addition to their automatic feeds the heads have fine hand adjustment for all movements, and it is stated that with reference to graduated dials adjustments to within 0·001in can readily be made. A large handwheel on the point of each head permits rapid vertical hand feed and it is locked by a smaller wheel. A rapid power traverse gear for all motions is driven by a 7½ h.p. motor on each head and engagement of the automatic feed clutch automatically cuts out the rapid power traverse. A slipping clutch device protects both feed mechanisms under all conditions.

The massive cross slide is of particularly rigid construction and, complete with the heads, feed boxes, balance gear, and platform weighs 54 tons. Power for raising and lowering this slide is provided by a 22½ h.p. motor mounted on top of the fixed tie beam for the uprights, and the drive is transmitted through a cross shaft to a heavy worm and worm wheel attached to the elevating screws in the uprights. The thrust is taken on heavy roller thrust bearings, and safety nuts are fitted below the normal elevating nuts. Each elevating screw is provided with a micro dial gauge which registers thread wear, and this enables precise horizontal alignment of the cross slide to be maintained indefinitely. The cross slide is locked by gear operated by two 2 h.p. motors, which are interlocked with the main table motor to prevent the table being in motion with the cross slide unlocked.

The uprights are of the firm's new buttressed design, and that on the right hand side of the machine is fitted with a vertically adjustable measuring block which provides a datum for using gauge rods when setting work on the table.

The 22ft diameter table is supported on two flat bearing tracks and has an adjustable-taper cast iron centre spindle. In view of the heavy working loads the table is designed to take, the makers have introduced a method of indicating to the operator the temperature of the bearing tracks whilst the machine is in operation. Six thermo-couples fitted on the tracks and spindle are connected to a temperature recorder on the control desk of the machine. In a window of this recorder the temperature at each of the thermo-couple positions is indicated in turn.

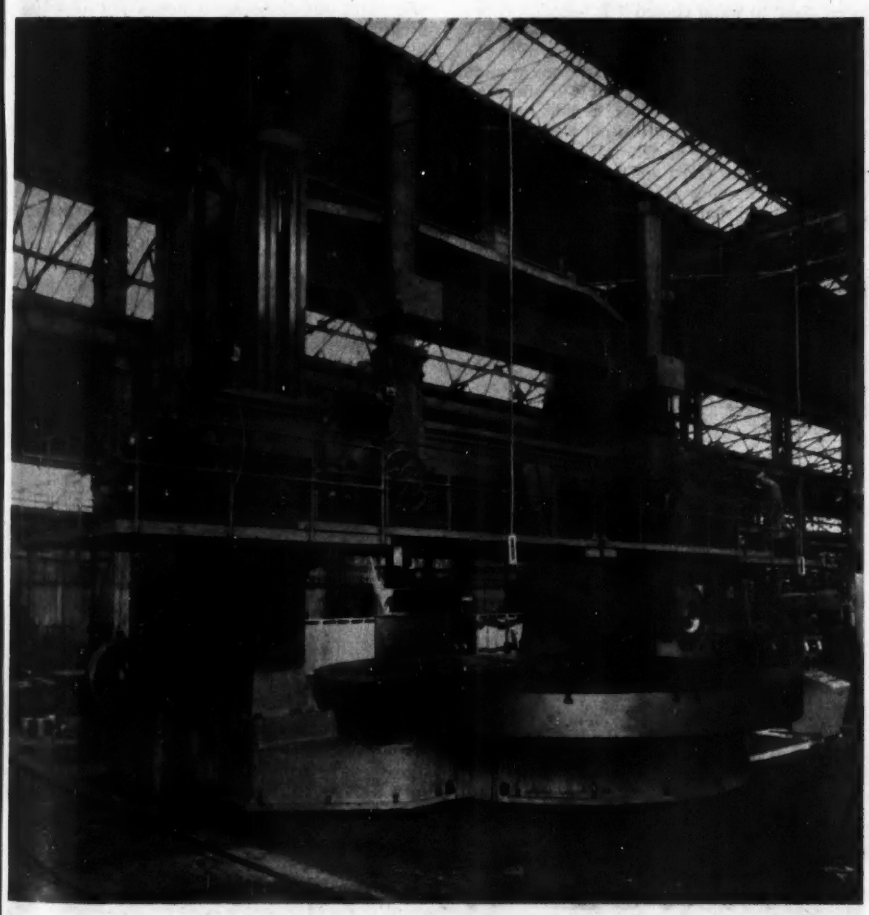
Control cabinet for boring and turning mill

The table is driven by a 120 h.p. three-to-one variable speed d.c. motor, having a speed range of 300 to 900 r.p.m., and a three-speed gearbox. A ¾ h.p. motor on the gear box is used for selecting the required gear ratio, and the range of table speeds available is from 0·33 to 9 r.p.m. The push-button controls for the machine are centralised on a cabinet and pendants. In addition to the main motor and gearbox controls on the cabinet, push-buttons for controlling the elevation, stopping, locking and unlocking of the cross slide are provided. Lights indicate whether the particular mechanisms are locked or unlocked. An emergency stop button for the whole of the electrical equipment and ammeters for gear change and main motors are also provided.

A seven-point pendant push-button station at each side of the machine controls start, stop and inch of the main motor, and feed on, feed off and forward and reverse to the tool heads for rapid power traverse.

Lubrication of all the main bearings is entirely automatic. The main oil system, fed by two rotary pumps driven by a 1½ h.p. motor, ensures that the table spindle, bearing tracks and other important bearing surfaces are adequately lubricated. To ensure that all these points are oiled before the table is started, the oil circulates and is finally returned to the distributor tank by cascading over two tray switches. These tray switches ensure that the main motor will not start until the trays are filled with oil which tilts the arms to close an electrical circuit. This system also ensures that the main motor is switched off if the oil system breaks down.

The whole automatic control gear for all motor drives is housed in a separate cabinet at the rear of the machine. Full protection against overload or failure of voltage is provided for all motors and includes an isolator switch interlocked with the cabinet doors.



Double standard vertical boring and turning mill with maximum swing of 25ft 3in and designed to handle work weighing up to 90 tons

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TWO OIL FILMS.—On four days last week, The Shell Petroleum Company, Ltd., exhibited two films made by the Shell film unit. The first film, entitled "Proud Ships," told the story of one ship of the company's fleet and illustrated life at sea and in port, and some of the world-wide network of transport employed in the handling of oil. The second film, "The Oilmen," gave an overall view of the activities of the Royal Dutch/Shell group from the search for oil, and the drilling for oil to its shipment by pipeline and ship to the refineries and the subsequent distribution of the finished product. The world-wide character of the operations of the group was illustrated together with a representation of the variety of skills utilised in the production of oil.

Medical Research Council's Cyclotron

The cyclotron at Hammersmith Hospital, which is the first hospital to be thus equipped, is now nearing completion. It is a 45in machine, and in preliminary trials an internal beam of 30MeV alpha-particles has been obtained and beam currents of up to 750 micro-amps. of singly charged hydrogen molecular ions have been measured at 6in radius. It is erected above ground surrounded by 6ft thick concrete walls and roof.

IT is five years since the Medical Research Council authorised the building of a cyclotron by the Radiotherapeutic Research Unit at Hammersmith Hospital. The machine is now almost complete, although some time must elapse before it comes into routine operation. In preliminary trials an internal beam of 30 MeV alpha-particles has been obtained, and beam currents of up to 750 micro-amps of singly charged hydrogen molecular ions have been measured at 6in radius.

This is the first time that a cyclotron has been installed in a hospital, a fact which rendered it especially necessary to make the machine as simple and as reliable as possible, and to pay particular attention to ease of maintenance, since the equipment will have to be in constant operation.

The cyclotron is one of the most versatile of all the particle accelerators, and the presence of such a machine in a hospital will make possible the use of a large number of techniques which have not hitherto been available to therapy and medical research. Its principal products are neutron and charged particle radiations, and radioactive isotopes.

In the allied subjects of radio-biology and radiation chemistry, beams of fast charged particles such as deuterons, alpha-particles or protons are frequently employed. The cyclotron is particularly useful in this respect as it is capable of producing a large beam current at an energy that is great enough to give adequate penetration into the specimen to be irradiated.

Most of the nuclear reactions produced by bombardment in a cyclotron result in a radio-active isotope which is chemically different from the target material from which it is made, with the result that it is easy to obtain carrier-free isotopes and hence the high specific activities which are required for therapeutic and diag-nostic work. By comparison, a nuclear reactor can produce isotopes at a greater rate, but usually not of such high specific activity. Moreover, with the cyclotron situated near to where its products are required, isotopes of short half-life may be utilised ; i.e. those the activities of which decay to half their value in a matter of minutes or even seconds.

The Cyclotron Magnet.—The M.R.C. cyclotron is a 45in machine, the magnet core consisting of eight pieces. Four of these, constituting the yoke, are of solid forged blocks, the horizontal members weighing about 32 tons and the vertical members about 14½ tons. Each pole consists of two flat discs of 57in diameter and 22in and 8·68in thick, respectively. The coils are con-structed from rectangular section aluminium tube having external dimensions 1·15in by 0·75in, and with an internal bore of 0·4in diameter. There are 408 turns on each coil, which carries 560A at full load to give a maximum field strength of 17 kilogauss across a total effective gap of 8in. Pole faces are parallel and concentric to within 0·0035in and 0·005in, respectively. The whole magnet stands on a plinth composed of a steel framework bolted to the floor and concreted in position.

Cooling of the magnet coils is by means of distilled water which circulates through the hollow conductors of the coils and delivers up its heat, through heat exchangers in a room on the first floor, to a second circulating system containing ordinary tap water. This second system circulates the tap water between the heat exchangers and the evaporative cooling towers on the roof. In order to minimise the possibility of electrolysis, the system is of aluminium and stainless steel throughout.

The lids of the vacuum box form the pole faces and are constructed from "Armco" iron. They are 3in thick and copper plated on the inside face. Behind each of the pole faces a 1in shimming gap is provided. The vacuum box itself is a brazed assembly of rolled brass. Pro-vision has been made for the easy fixing of central shims to the inside faces of the vacuum box lids, and peripheral rose shims are screwed to the lids. The dimensions of these were established to a first order on a model magnet, and then experimentally on the cyclotron magnet. The assembly of magnet and vacuum chamber is shown in the accompanying Fig. 1.

Electrode System.—This consists, in the usual manner, of two hollow "dee"-shaped electrodes, placed face to face in the magnet gap. Ions generated at the centre are accelerated under the alternating electrostatic field, produced when a radio-frequency voltage of 11,286 megacycles per second is applied to the "dees." Under the action of the magnetic field the ion beam moves along a spiral path until it hits an internal target or is conducted out of the cyclotron.

The "dee" stem housing consists of a copper sheath enveloping the two stems to form a shielded pair. Such a system has the advantages of low radio frequency losses and of allowing high vacuum pumping speeds. The measured Q is 4550.

The "dee" stems are mounted on gimbals, situated in the vacuum take-off box, to allow deviations in the "dee" positions, due to heat expansion, &c., to be corrected by remote control while the machine is running. To allow for this movement the short circuit is composed of forty-eight water-cooled "S"-shaped copper tubes, fixed to water cooled "T"-section copper pipes soldered to the parallel section copper liner and "dee" stem casings, respectively. The number of these strips required to prevent undue radio-frequency leakage behind the short was determined experimentally on a model. Maxi-mum losses in the short are about 5kW.

A short-circuited horizontal loop has been provided near the short and between the "dee" stems. By moving this loop vertically, the coupling to the stems is varied and it is possible to shift the resonant frequency of the electrode system by 2·5 per cent. Maximum losses in this loop are of the order of 10kW.

Ion Source.—The ion source is of the hooded type and is a modified version of that originally developed at Washington University, St. Louis, and has a hair-pin filament set vertically, a technique recently developed by Rossi at the University of California. The filament is fed from a 500A 6V generator and the power to the arc is provided by a 600V 6A mercury arc rectifier. The filament and the hood can both be withdrawn through gate valves and the position of the ion source head is adjustable from outside the "dee" box in three directions.

Vacuum System.—The vacuum pumps con-sist of two sixteen inch "BAR" diffusion pumps backed by two "Kinney" mechanical pumps of 200 cubic feet per minute total capacity. In combination with refrigerated baffles the system has a pumping speed of 4000 litres per second at 10^{-5}mm Hg for a volume of 4000 litres. The vacuum pumps and the rest of the electrode system are cooled by distilled water passing through a system similar to that for the magnet, but constructed from copper. A pressure of 5×10^{-5}mm Hg can be reached in two hours and 5×10^{-6}mm Hg can be obtained in two days. The leak rate is stated to be six microns per hour. The pump unit is shown in Fig. 2.

Radio-frequency System.—The radio-frequency generator consists of a crystal controlled Federal Telephone and Radio Company transmitter, type FT 300, having an output of 12kW. This is used to drive two neutralised BW 165 valves of 22·5kW anode dissipation. The radio-frequency system is capable of an output of 75kW and works at a fixed frequency of 11,286 megacycles per second. The "dee-dee" voltage for 100kW d.c. power input is greater than 200kV peak. Amplifier efficiency is about 70 per cent and power gain about 14 per cent.

The Building

The building is 250ft long by about 48ft wide, and was designed to house not only the cyclotron and laboratories necessary for research workers using this machine, but also an 8,000,000V linear accelerator used for the treatment of patients. It is situated in the north-east corner of the hospital grounds and is four storeys high, except at the north end of the building, which contains the cyclotron suite, and the extreme south end, in which is housed the linear accelerator treatment room. It has been designed as an eight storey building.

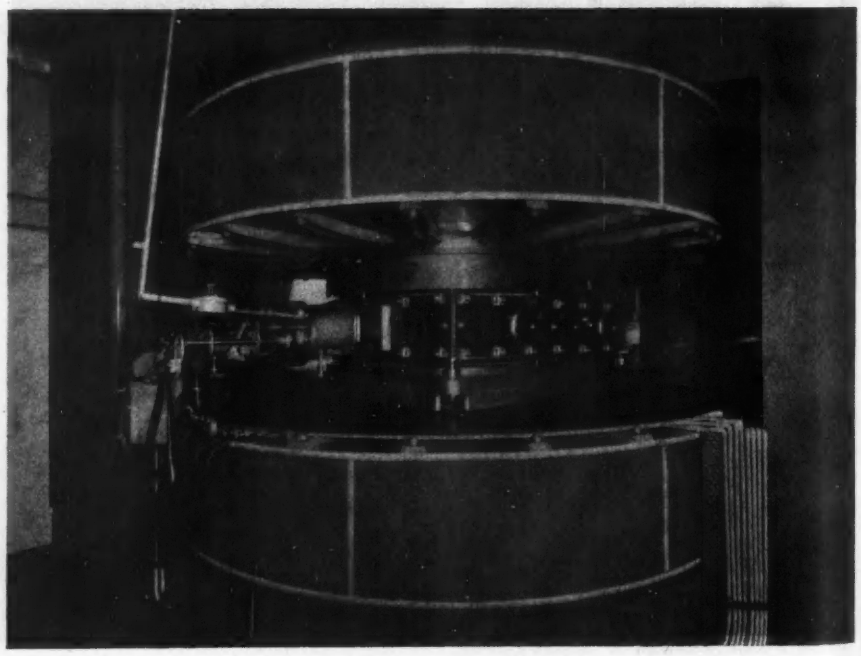

Fig. 1—Cyclotron assembly with vacuum chamber containing the "dee" electrodes

Fig. 2—The pump unit and its control panel

The ground floor of the central block as far north as the stair tower is occupied by the clinical facilities serving the 8 MeV linear accelerator. North of the stair tower is the cyclotron workshop and control room and then the suite itself, which is a two storey building. On the first and second floors are laboratories occupied by the Radiotherapeutic Research Unit and the Experimental Radiopathology Research Unit.

Cyclotron Chamber and Assembly Bay.—Most cyclotrons are built below ground or into the side of a hill to reduce the cost of shielding the radiations that come from the machine. The Hammersmith site, however, is quite flat and the merits and demerits of placing the machine below ground level had to be carefully considered. It was finally decided to erect the cyclotron above ground, in a chamber whose walls and ceiling, except at the south end, are composed of concrete 6ft thick. The chamber is approximately 44ft long by 20ft wide by 13ft from floor to ceiling. Below the floor level is a 4ft deep basement in which are housed the various cable and pipe runs, the floor being made of 3ft 6in by 2ft concrete slabs supported on brick walls.

Health reasons require that between 4ft and 6ft of concrete should surround the machine. However, it is particularly desirable that switching the cyclotron on and off should not unduly affect sensitive apparatus used for low intensity radiation counting in the main building. It was decided that interference from the machine should not exceed the equivalent of cosmic ray background, and on this basis the door at the south end of the chamber into the assembly bay had to be 10ft thick. Due to the limitations of the site it was not possible to reorient the chamber and avoid this large door, which weighs 190 tons and moves on rollers into a "garage" on the west side of the building when in the open position. When closed the door fits into the wall and ceiling with a maximum clearance of half an inch.

When the door is open a double leaf drawbridge closes over the pit on which are two rails over which the whole of the electrode vacuum assembly can be wheeled out on a trolley into the assembly bay.

The assembly bay contains two overhead runways with 5-ton blocks and tackle and is two storeyed on the east side. The west wall consists of a glass panelled folding door giving direct access on to the road.

Access to the radiation room, i.e. the space north of the magnet, is through an opening in the east wall which is closed by a door consisting of steel loaded concrete in a steel tank 3ft thick. This door operates on a similar principle to the south door, and weighs 35 tons. When the door is fully closed it uncovers a water window through which the cyclotron may be viewed during operation.

Control Room.—Considerable thought has been given to the design and layout of the control room (Fig. 3), in order to minimise fatigue for operators who may be working there for long periods. It was decided to exclude all daylight and to rely entirely upon artificial lighting. The bank of lights over the control board gives a uniform illumination of about 20ft candles, and can be dimmed to suit the preference of the operator. The whole machine can be operated from the control desk, reference to the control board only being necessary at the commencement of operation or if a fault develops. For special experiments, additional apparatus such as oscilloscopes or counters can be placed near the operator on two detachable wings fitted to the desk for this purpose.

Normally the experimenter will be stationed at the east door, where he can observe the machine through the water window mentioned above. He is in touch with the operator in the control room by means of a microphone-loudspeaker system.

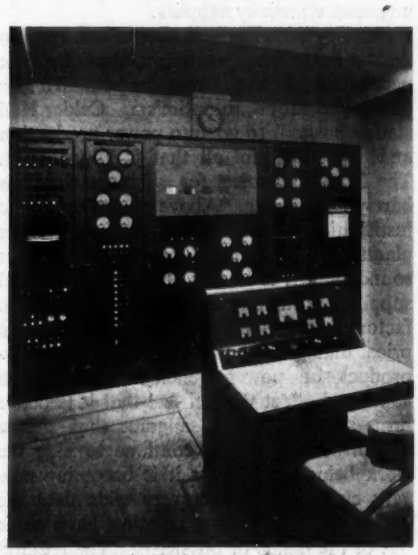

Fig. 3—Control desk, with control board in background. Normal running is controlled from the desk

Plant Rooms and Laboratories.—Two plant rooms lie along the outside of the east wall of the cyclotron chamber. In the ground floor room are the 165kW motor-generator set and control gear which supply the magnet, an auxiliary motor-generator set and the 10kV, 100kW high voltage rectifier, for the radio-frequency power amplifier. The first floor plant room consists of a series of wire-cages containing the battery room, the high voltage deflector set for operation at up to 200kV, and the radio-frequency driver stage of four 3kW, 10 megacycles per second oscillators. These plant rooms are connected to the chamber by 9in internal diameter ducts passing at an acute angle through the wall.

At the north-east corner of the cyclotron suite on the first floor is the cooling and ventilating plant room. In it are housed the heat exchangers for the cyclotron and the air conditioning plant for the chamber. Air conditioning is designed to keep the relative humidity below 50 per cent to avoid rusting of the machine. The air is drawn in over cotton flock filters and delivered through a labyrinth past a bank of 15kW heaters to the chamber.

On the roof of the chamber is a small house containing the evaporative coolers, which dissipate the 300kW of heat losses generated when the cyclotron is running.

On the east side of the suite are two floors of laboratories. On the ground floor at the north end are two target chemistry laboratories, and next to these, two general purpose rooms.

2000 H.P. Electric Locomotives for South African Railways

THE first of sixty 2000 h.p. electric locomotives for service on the South African Railways' main line between Glencoe and Pietermaritzburg has been delivered by the English Electric Company, Ltd. These locomotives are of B_0–B_0 type, weigh 83 tons, are capable of a maximum service speed of 60 m.p.h. and will negotiate a minimum curve of 4 chains. They are equipped with regenerative braking.

The locomotive underframe, of rolled steel sections and plates, is reinforced at its ends for the attachment of drawgear. The bolster is supported by two semi-spherical grease-lubricated side bearing pads, which form the upper half of manganese-steel-lined sliding surfaces. The two lower halves of the sliding surfaces are integral with a cast steel tie beam, which joins a set of leaf springs at either side of the bogie. The ends of each spring are suspended from the bogie frame by means of inclined swing links. Each wheel has its own brake cylinder operating a pair of clasp brakes.

The four forced-ventilated traction motors each develop 500 h.p. at the one-hour rating, and are insulated for the full line voltage. Three stages of field weakening are provided by a combination of a field tap and divert resistances.

Most of the high-tension control gear is carried in two frames. The low-tension control equipment consists of electro-magnetic contactors for compressor, exhauster, battery charging, train line supply and regenerative brake excitation control. Mounted on the roof are two pneumatically operated pantographs, a surge absorber, pantograph isolating links and a horn gap.

For motoring, all four motors are initially connected in series with the starting resistance which is progressively cut out in steps as the accelerating handle is notched up. On reaching the "full field" position all resistance is cut out of circuit. An increase of speed can then be obtained by advancing the accelerating handle to any of the weak field positions. Further speed increases can be obtained by connecting the motors in two parallel groups of two motors in series, by selecting parallel operation on the combined "transition and reverse" lever and returning the accelerating handle to the first notch. The accelerating handle can then be notched up to the full field position, and any of the weak field positions are also available.

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PROGRESS OF NUCLEAR POWER

The report in our last issue that the Institutions of Civil, Mechanical, Electrical and Chemical Engineers, together with the Institute of Physics, have combined to set up the British Nuclear Energy Conference prompts us to reflect how startlingly rapid have been advances in the world's knowledge of the technology of nuclear power. When an atomic bomb burst over Hiroshima in 1945 it was revealed to the world for the first time that an effective means of converting mass into energy had been found. A major task remained, however. This source of energy had still to be harnessed for the provision of useful instead of destructive power. There were very few optimists at that time. For those with intimate knowledge of what had already been done could foresee formidable engineering difficulties ahead and the economics of nuclear power generation were heavily clouded with doubts. Few, indeed, of those who helped to bring the project for the construction of atomic bombs to fruition can have believed ten years ago that a power station capable of generating power in significant amounts and at anything approaching an economic cost could by this time be nearing completion in this country. None surely would have dreamed it possible that in 1955 a detailed plan could be drawn up for the construction, at a cost of £300 million, of a number of such stations within ten years; nor that industrial firms could be contemplating commercial manufacture and looking forward expectantly to the receipt of orders not only from the Central Electricity Authority, but from abroad. In this country the suddenly quickened interest in the possibilities of nuclear power aroused in the last few months dates from the setting up in August, 1954 of the United Kingdom Atomic Energy Authority and the subsequent tearing down of the veils of secrecy which had up to that time concealed how much progress was being made. As a consequence of the revelation industrial firms which formerly, in the belief that many years of research still lay ahead, had taken little interest in the industrial possibilities of nuclear power development began almost to fall over themselves to gain knowledge as quickly as might be and to link themselves into groupings each capable of designing and manufacturing complete plants. Perhaps it is one of the consequences of that enthusiasm that the Minister of Fuel and Power was able to announce in the Commons last Monday that six more reactors of the Calder Hall type, additional to those included in the £300 million programme announced last February, are to be built. Their primary purposes will be to produce fissile material for military purposes, but they will also augment electricity supplies.

Possibly there has been too sudden and too great a swing from pessimism, about the time needed to develop reactors suitable for power generation, to optimism. Calder Hall station has still to go into power production and prove truthful all that is hoped of it. The Dounray project for a fast reactor has barely been begun. Above all the economic justification for the building of nuclear power plants abroad might prove to be less sound than it is in this country, where coal supplies are running short. For the uncertain factor in all economic calculations is the price that plutonium, produced as a by-product of power generation, ought to command. Yet we still feel that it is better firms should feel too sanguine than that a veil of secrecy should continue to hide the work being done. For it is becoming now very clear that over a very wide field the problems still awaiting solution have come out of the hands of physicists. The requirements are known, and they are far from easy to meet. But they create engineering rather than physical problems; problems of heat transfer, structural problems, problems of fluid flow and the design of pumping plant, problems of ventilation and filtration, metallurgical problems, and the like. For each of these problems—if history is any guide—there will prove to be not one, but a multiplicity of possible engineering solutions. It is common to find in the evolution of any engineering device that once its practicability has been demonstrated a variety of applications of the original idea need to be tried before, by a process of natural selection, the more effective can be found. The technology of nuclear power appears to stand upon the threshold of that stage in its development. The physicists have demonstrated what is fundamental; a small team of engineers is in progress of demonstrating that the generation of power is both practicable and economic. The next stage—as was clearly recognised when the U.K. Atomic Energy Authority was set up—is to spread knowledge widely so that as many talented minds as possible may not only gain experience of the engineering problems involved, but contribute new lines of thought and explore avenues of advance that have up to date been perforce neglected.

In the spreading of knowledge about the technology of nuclear power, the new conference of major institutions will certainly be able to play a notable part acting as a forum where views can be exchanged and storing in its records of proceedings the knowledge gained. It is possible to contemplate that in the more distant future nuclear power engineering may become so distinct a section of the whole engineering field that a new institution may become necessary. But that time is certainly not yet. We salute, therefore, the co-operative temper of the five institutions involved through which the by no means unreal danger has been scotched that such a body—likely to lead to an untimely new specialisation—might have been set up. Internationally, the forthcoming conference and exhibition at Geneva will provide an opportunity for demonstrating to the world how much progress this country has made since the war. We confidently expect, too, that that conference will help to break down still further the barriers of secrecy that still remain. For it is by no means improbable that it will show that, at least upon the more fundamental side, other nations besides the Americans and ourselves have been making discoveries and thereby demonstrate that advance could be still more rapid were it possible to exchange information more freely.

THE GOVERNMENT'S INTENTIONS

The only really surprising factor in the Queen's Speech to Parliament on Thursday of last week was the amount of its content. It had been thought that the new session would last only until next October. In the event, however, the Government decided to extend it until October of next year, thereby permitting the immediate formulation of a full programme of legislation and other activities. Naturally, the business to be transacted by the new Parliament includes the reconsideration of certain Bills, like that to amend the Road Traffic Acts, which failed to pass through all their stages before

the election. Much more activity, however, is also promised. Industries will be interested to see how the measure to amend the law relating to valuation and rating in England and Wales works out. They may find, too, that any proposals the Government may prove bold enough to make as a consequence of its examination of problems of local government in England and Wales will demand scrutiny and criticism. For much of the agitation of local authorities for the withdrawal of derating provisions from industry undoubtedly is rooted in the fact that many authorities deem themselves too increasingly dependent for finance on central grants and lacking independence in carrying on their own affairs. Proposals for reform of local government might thus have repercussions upon the rates industry has to pay, besides influencing a host of other activities falling within the purview of local authorities and affecting industry.

Amongst activities bearing more directly on the work of engineers it is good to see that a Bill " to reduce the pollution of the air by smoke and other causes " is to be introduced. When, some months ago, Mr. Nabarro drew up a Private Member's Bill to give effect to many of the recommendations of the Beaver report, it was withdrawn on the understanding that the Government itself would introduce a similar Bill before the session ended. In fact, owing to the intervention of the election, that promise could not be kept to the letter ; but it is being kept in spirit. Nevertheless, and all the more so because the measure is likely to prove uncontroversial in the party sense—Mr. Nabarro's Bill was strongly supported from both sides of the House—the Bill will need to be carefully examined when it appears. Some of its provisions may prove to bear hardly upon industry or may make extravagant demands upon the abilities of local authorities and their inspectors. It will be interesting also to see what " further action ... may be required in the public interest to deal with abuses in the field of monopolies and restrictive practices." We hope the Government does not intend to attempt to speed up the work of the Monopolies Commission. Undoubtedly there are restrictive activities and arrangements within industry. Recent examples, for instance, of identical quotations for plant by a number of engineering firms have excited criticism. But it is quite naive to assume that because restrictive arrangements exist they are necessarily bad. Cut-throat competition can often prove far worse by impoverishing the firms concerned and thereby delaying technological advance. That is not to suggest that some of the arrangements reached during years of depression may not continue to survive unnecessarily in the present era of greater prosperity ; just as some of the restrictive practices of trades unions adopted in those same years of depression with the object of maintaining employment have similarly survived to the detriment of advancing productivity to-day. But within any industry examined the situation has to be very carefully judged. Neither deep study can be given nor correct conclusions drawn unless adequate time is available. Moreover, experience suggests that, providing the situation is really exhaustively studied, the industries concerned prove very willing to modify any arrangements that can be shown to be against the national interest.

Some of the more general statements in the Speech merit attention also. There is, for example, the cryptic statement that " facilities for technical education will be extended." Does this foreshadow some activity likely to interest technical colleges ? Or does it merely refer to plans already outlined by the Government for extending educational accommodation at certain universities and colleges closely connected with universities ? The remark that the Government will " press forward their far-reaching programme of road construction and improvement " suggests an unexpected degree of complacency about the planned rate of expenditure on the roads. Those who have studied the economics of road transport or whose concern is with road safety or the movement of traffic in cities, can hardly be expected to agree that a programme is " far-reaching " when at the very best it is unlikely to prove sufficient to fit the roads outside cities for the very large numbers of new vehicles certain to operate upon them within the next few years and can have very little influence, indeed, upon solving the traffic problems of urban areas ! A substantially higher rate of expenditure than any yet envisaged by a post-war Government will certainly be needed if this country's roads are soon to be made safer and road transport costs are to be reduced. Nor if the rate of increase of industrial productivity continues to rise will improvement of the roads impoverish the railways. The whole transport system will be strained. Modernisation of the railways will be as much needed as modernisation of the roads.

Obituary

SIR CHARLES McLAREN, K.C.B.

We regret to record the death of Sir Charles Northrup McLaren, which occurred in London on June 8th. Sir Charles, who was fifty-six, was director-general of the Royal Ordnance Factories during the second world war. On account of failing health, however, he was compelled to seek early retirement from the Ministry of Supply in October, 1951.

Sir Charles was born in Glasgow and was educated at Bellahouston Academy and at the Royal Technical College, Glasgow. He joined the Civil Service in 1931 as labour superintendent of the Royal Ordnance Factories, and four years later became superintendent of the Royal Gun and Carriage Factories. In 1936, Sir Charles was appointed assistant director of the Royal Ordnance Factories, in which position he took a large share of the task involved in reorganising and extending the factories when the rearmament programme prior to the war was decided upon. Towards the end of 1940, when the war had entered its most critical phase, Sir Charles was invited to succeed the late Sir Reginald Townsend as director-general of the Royal Ordnance Factories. In that very responsible office, he demonstrated not only his technical ability but also those qualities of leadership and encouragement which were characteristic of him. His personal contribution to the war effort during those perilous days was indeed enormous. In 1941, Sir Charles was created K.C.B. in recognition of his valuable services. Sir Charles was a member of the Institution of Mechanical Engineers and of the Institution of Production Engineers. He was also, for a period after the war, chairman of the Gauge and Tool Advisory Council.

SIR ATHOL ANDERSON, K.C.B.

We record with regret the death of Sir Athol Lancelot Anderson, which occurred at Hove, on Tuesday, June 7th. Sir Athol, who was in his eighty-first year, was Civil Engineer-in-Chief at the Admiralty from 1934 until his retirement in 1940. He was born at Sydenham, was educated at Cheltenham College, and was subsequently articled to the late Sir James Lemon for training as a civil engineer. Sir Athol began his service with the Admiralty in 1901, and as an assistant civil engineer was stationed at several naval establishments in this country and abroad. During the first world war he served in the Far East with the R.N.V.R. In 1929 Sir Athol was appointed superintending civil engineer at the Admiralty and three years later he was promoted to the position of deputy Civil Engineer-in-Chief, becoming Civil Engineer-in-Chief in 1934. The honour of C.B. was conferred on Sir Athol in 1936, and in 1939 he received his K.C.B. Sir Athol had been a member of the Institution of Civil Engineers since 1900, and had served upon its council. He had also served on the Commission des Travaux of the International Commission of the Suez Canal.

TOM THORNYCROFT

Yachtsmen and yacht designers will have learned with considerable regret of the death of Mr. Tom Thornycroft, which occurred on Monday, June 6th, at his home, Tidnock Farm, Overton, Hampshire. Mr. Thornycroft, who was the second son of the late Sir John I. Thornycroft and brother of Sir John E. Thornycroft, the governing director and chairman of John I. Thornycroft and Co., Ltd., the shipbuilders and engineers, was born at Basingstoke in November, 1881. He was trained as an engineer and for some twenty-one years, until he severed his connection with the family business in 1934, was general manager of the motor vehicle works at Basingstoke of the company. During this time he was responsible for the design of the light cars, then manufactured by the company, and took part in many racing events and reliability trials. Tom Thornycroft had much to do with the development of the early paraffin vaporising engine and also with the design of the Thornycroft diesel engine, which eventually superseded the earlier unit. His interest also extended to motor boats and the design of the coastal motor boats of the first world war was largely based on experiments carried out by Tom Thornycroft and his father.

All his life he was interested in small boats and yachting, and won his first prize at the age of fourteen. He was a member of several yacht clubs, including the Bembridge Sailing Club, which he joined as long ago as 1895. However, his interest did not stop at the sailing and handling of small craft, but was extended to include their design, and although not in practice, many designs came from his drawing board, including that of his own 70-ton yacht, " King Duck," which he sailed to Helsinki to attend the 1952 Olympic Games.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

CANTILEVERED PITOT CYLINDER

SIR,—In your issue of May 27th, you published an article on the "Cantilevered Pitot Cylinder," in which the writer discussed the suitability of this type of instrument for determination of pressure, velocity and flow direction.

There are two types of error that occur with this instrument which were not directly mentioned. They are both encountered in regions of velocity gradient in a direction perpendicular to the flow—such as the wake from a blade or the boundary layer on a wall.

The first is an error in the measurement of flow direction: in a case where the flow is parallel to the datum direction, there will be a total pressure gradient perpendicular to the flow, and this will be recorded as a yaw in the flow. For this reason it is not usually practicable to use the instrument as a yawmeter under these conditions.

The second is a "displacement" error in the reading of pitot pressure. The writer of the article states that wall proximity within the test conditions did not affect the cylinder total pressure readings. However, some unpublished work which I have seen shows that the pitot reads high, as though it were situated at a position $0{\cdot}09\,D$ (where D is the probe outer diameter) nearer to the higher total pressure. This is similar to the displacement error observed with the probe type of pitot tube (see reference 1). This error can be allowed for by suitable calibration of the instrument, although it becomes large within $0{\cdot}2\,D$ of the wall, and the instrument cannot then be used with any accuracy.

Linby, Notts, June 6th. W. F. WILES

Reference 1.—Livesey J. L. Design of total pressure tubes for minimum interference with measured flow. *Journal of the Aeronautical Sciences.* Page 641, September, 1954.

LAST OF THE AMERICAN "CAMELBACK" LOCOMOTIVES

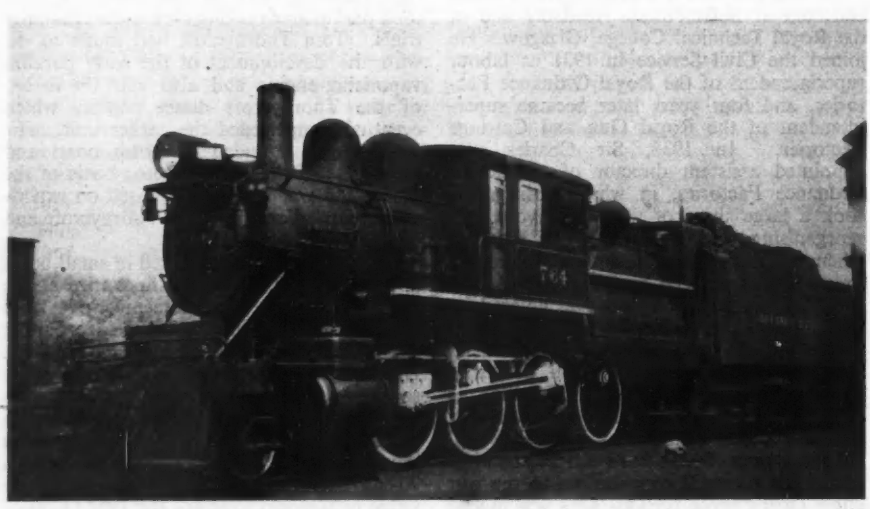
SIR,—An interesting locomotive which was used fairly extensively on some American railroads from 1899 onwards was the "Camelback" or "middle cab" type.

The type composed many different wheel arrangements, including 4-4-0, 4-4-2 and 2-6-0. It was used both in express passenger and freight service and the Reading Railroad, Central Railroad of New Jersey and the Lehigh Valley used all these types. In the past it was notable that the "Camelback" "Atlantics" of the Reading Company had put up some remarkable instances of high speed running with trains of more than 290 tons, which at the time compared most favourably with some of the high speeds then being maintained on American railroads. Among the last roads to retain the "Camelback" engine in service, both on passenger but more extensively on freight duties, was the Delaware and Hudson Railroad. The illustration shows No. 764, a 2-8-0 "Consolidation Camelback" of the D. and H. which my correspondent believes was the last of its kind to remain in service. When the photograph was taken on June 13, 1946, at Whitehall, N.Y., the engine had been in the shops for a major repair and, as was the custom on the D. and H. when an engine was so treated, the main rods, wheel-tyres and edges of the running-boards had been given a coat of white trimming. No. 764 was "outshopped" in 1901, so was forty-five years old when the photograph was taken. The "Camelbacks" rendered good service when they first appeared, but towards the end of their career they were considered somewhat unsafe, as, of course, the engineer and fireman are separated and the type has been gradually withdrawn.

The high speed performances attained by the Reading 4-4-2 was made when they were practically new engines, just after building.

A. J. RICHARDS

Tyseley, May 25th.



"Camelback" locomotive of the Delaware and Hudson Railroad

Birthday Honours

THE list of Birthday Honours, to be conferred by Her Majesty The Queen, was issued on Thursday of last week, June 9th. The following are included in the awards to engineers, scientists and industrialists:

Baron.—Sir Geoffrey Heyworth, chairman of Unilever Ltd.

Baronet.—Sir George H. Nelson, chairman and managing director of The English Electric Company Ltd.

Knights Bachelor.—Mr. Harold Bishop, M.I.E.E., director of technical services, British Broadcasting Corporation; Mr. J. C. Denholm, president, Chamber of Shipping of the United Kingdom; Mr. A. W. Grant, chairman, Engineering and Allied Employers' West of England Association; Mr. R. M. Shone, executive member, Iron and Steel Board; Captain Cyril I. Thompson, Commodore Captain of the "Queen Elizabeth"; Mr. H. E. Watts, lately H.M. Chief Inspector of Explosives, Home Office; Mr. J. P. Tivey, for services to engineering, science and industry in Australia.

C.B.—Engineer Rear-Admiral J. E. Cooke; Mr. G. W. H. Gardner, Director-General of Technical Development (Air), Ministry of Supply.

C.M.G.—Mr. H. G. Conde, chairman of the Electricity Commission, New South Wales; Mr. J. R. Dridan, engineer-in-chief, Engineering and Water Supply Department, South Australia; Lieut.-Commander J. Jolly, R.N.R.(ret.), Director of Marine, Hong Kong; Mr. H. A. W. Morrice, Director of Irrigation, Sudan Government.

G.B.E.—Sir William E. Rootes, chairman, Dollar Exports Council.

K.B.E.—Sir George Burt, president, Federation of Civil Engineering Contractors; Dr. A. Fleck, chairman, Imperial Chemical Industries Ltd.; Sir Harold Spencer Jones, F.R.S., Astronomer Royal; Mr. W. Hudson, chairman, Snowy Mountains Hydro-Electric Authority; Major-General J. E. S. Stevens, chairman, Australian Atomic Energy Commission.

C.B.E.—Brigadier Clarence Kirk, late Corps of Royal Engineers; Mr. W. B. Brown, Divisional Inspector of Mines, East Midland Division, Ministry of Fuel and Power; Mr. E. Butler, senior engineering inspector, Welsh Office, Ministry of Housing and Local Government; Mr. A. E. Childs, Director of Chemical Research and Development, Ministry of Supply; Major C. R. Dibben, chairman, Midland Regional Board for Industry; Mr. J. V. Dunworth, head of Reactor Physics Division, Atomic Energy Research Establishment, Harwell; Mr. C. H. Dutton, vice-chairman of Rotax Ltd.; Dr. G. E. Foxwell, consulting fuel technologist; Mr. R. W. L. Gawn, superintendent, Admiralty Experimental Works, Haslar; Mr. G. H. Houlden, managing director of the shipbuilding division, Vickers-Armstrongs Ltd.; Mr. R. L. Lawson, Deputy Director of Armament Supply, Admiralty; Mr. C. E. Lucette, manager of the Manchester Ship Canal Company; Mr. R. W. Lunn, technical director, Leyland and Birmingham Rubber Company Ltd.; Mr. C. G. Mant, Deputy Director General of Works, Ministry of Works; Mr. C. G. Morley New, for services to the electricity industry; Mr D. D. Pratt, Director of the Chemical Research Laboratory, D.S.I.R.; Mr. H. P. R. Scott, joint managing director of Summersons Foundries Ltd.; Mr. H. E. Steel, Chief Ship Surveyor, Ministry of Transport and Civil Aviation; Mr. F. N. Sutherland, general manager of Marconi's Wireless Telegraph Company Ltd.; Mr. R. E. Swift, Director of Aeronautical Inspection, Ministry of Supply; Mr. H. G. Taylor, for services to the chain and chain cable industry; Mr. J. L. Thomson, Professor of Mechanical Engineering, Royal Military College of Science, Shrivenham; Mr. J. N. Toothill, general manager of Ferranti Ltd., Edinburgh; Mr. P. B. Walker, Deputy Chief Scientific Officer, Royal Aircraft Establishment; Mr. Alexander West, chairman of the River Welland Board; Mr M. S. Maitland, general manager, Fields and Pipeline, Iraq, Iraq Petroleum Company Ltd.; Mr. P. A. T. Chrimes, chairman, Singapore Harbour Board; Mr. W. Fairley, chief civil engineer, Crown Agents for Overseas Governments and Administrations; Mr. Gordon Gibson, chief mechanical engineer, East African Railways and Harbours.

Atomic Reactors

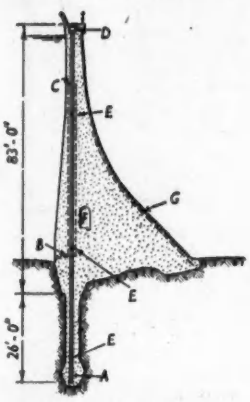
DURING the debate on the address in reply to the Queen's Speech, the Minister of Fuel and Power, Mr. Geoffrey Lloyd, announced, on Monday, that six more atomic reactors designed to produce fissible material for military purposes, as well as electricity, were to be built. He said that these reactors, which would be of the same design as the two now under construction at Calder Hall, were additional to those proposed in the £300 million programme which the Government announced in February. Two of the new reactors, the Minister continued, would be sited at Calder Hall, and the other four would be on a site chosen for its suitability and proximity to the chemical processing plants at Windscale in Cumberland. This work, the Minister added, was to go full speed ahead; it would produce a useful contribution of electricity to the grid within the lifetime of the present Parliament.

Fifth Congress on Large Dams

No. II—(*Concluded from page* 813, *June* 10*th*)

The fifth international congress on large dams organised by the International Commission on Large Dams of the World Power Conference was held in Paris at the beginning of this month. The four "questions" discussed at the congress formed the subject of our article last week; here some of the outstanding work recorded in various national contributions to the congress is mentioned.

IT is a peculiarity of British civil engineering that a substantial part of its work is carried out overseas. Only in overseas projects can British engineers find the rare opportunity of building dams of the largest size, for at home the scale of the countryside is too small to require more than comparatively modest structures. The first large arch dam to be built by British engineers will be, we believe, the Dokan dam in Iraq; several large-scale projects are also to be carried out in African territories. But all these works are at a comparatively early stage and were not mentioned at the fifth congress. Nevertheless, some interesting work was recorded by the British delegates, and it would be wrong to assume that, because the Scottish hydro-electric



A—Cone anchorage chamber.
B—Bottom of temporary shaft.
C—Top of temporary shaft.
D—Top achor plate.
E—Bar couplings.
F—Inspection gallery.
G—Light mesh reinforcement.

Cross section at anchorage pit of prestressed concrete dam at Allt-na-Lairige

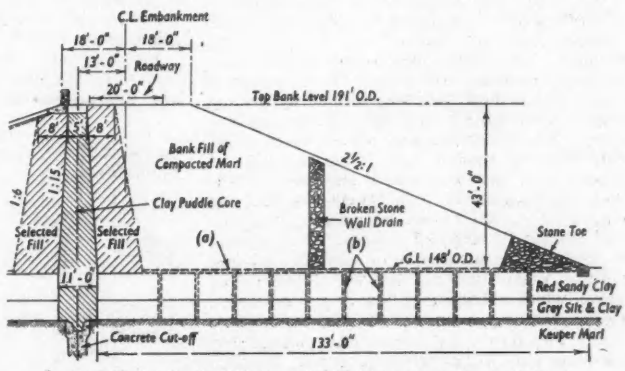
schemes, for instance, are smaller than many overseas, that there is necessarily less of technical interest and accomplishment in their design.

Recent work in Scotland was exemplified by about half a dozen papers, describing, for instance, the heightening of Mullardoch dam (R.12) and a hydraulic model investigation of the right-angled bend at the foot of a spillway shaft (C.13). The prestressed concrete dam under construction at Allt-na-Lairige was described by J. A. Banks (R.68), and the accompanying cross-sectional illustration is reproduced from his paper.

The Allt-na-Lairige scheme, as originally designed, had a rather limited storage, but the cost of any increase in the height of the dam reflected adversely on the unit cost of the power generated. The prestressed concrete design, however, permitted a dam of greater height, which would increase the storage from 8·3 to 10 per cent of the average annual run-off for practically the same capital expenditure as the original gravity design. Construction of the dam will be completed, it is thought, by the end of this year. The paper describes the test anchorages built to obtain design information, and briefly outlines the design procedure. The dam is prestressed according to the Lee-McCall system, with a prestress of 56 tons per foot run. There are twenty-eight 1¼in diameter bars in each anchorage, which are extended by coupling as the work proceeds; the prestressing force at each anchorage is 1176 tons. The prestressed section of the dam is 987ft in length (the entire dam is 1360ft long) and the anchorage pits are spaced at 21ft centres.

In question 17 of the congress, in which the relative merits of different types of dam were discussed, some recent examples of the massive buttress design, of which the Loch Sloy dam is the prototype, were described by Chapman and Campbell (R.61). This design, the authors state, is particularly suitable for Scottish conditions. In the more recent dams at Lubreoch and Giorra, the design has been modified to give greater constructional speed and simplicity. Mass concreting methods are used for almost the entire structure, minor details being precast. The arch rings carrying the roadway, which are so prominent at Sloy dam, have been eliminated at Giorra dam to simplify the construction still further, enabling the standard shutters to be used for the full height of the dam. A cost analysis is given, from which it is concluded that for a dam 120ft high the estimated cost of a massive buttress design of this kind has now been reduced to 60 per cent of the cost of an equivalent solid gravity dam.

Our second illustration is reproduced from the paper by Skempton and Bishop (R.57) and shows the embankment built to form the Bristol Waterworks Company's Chew Stoke reservoir. The point of interest here is the use of sand drains to relieve the pore water pressure in the newly constructed embankment. The use of sand drains in an earth dam 110ft high—the Usk dam—is also described by Sheppard and Little (R.59). In both cases measurements have been carried out on the site, to ascertain the effectiveness of the sand drains, and there careful site investigations enhance the value of the papers considerably. In the case of the Usk dam the sand drains relieve the pressure in a silt layer beneath the dam's foundations, and offered a more economical design than the alternative of digging out the silt.



(*a*) Sand blanket 9in in thickness underlain by transverse French drains at 60ft centres. (*b*) Sand wells 9in in diameter at 10ft centres.

Cross section of the Chew Stoke embankment showing sand drains

Trial pits opened for the Chew Stoke dam revealed that the lower part of alluvium at the site included a layer about 5ft in thickness of soft dark grey clay. Under these conditions there was a danger of a foundation failure during construction, which was of great practical importance as impounding was to begin before the embankment was completed, and the water level was to be raised progressively with the embankment.

It was therefore necessary to decide whether the gain in strength of this soft layer due to consolidation under the weight of the embankment would be sufficient to ensure an adequate margin of safety at all stages, or whether all the alluvial material should be removed and replaced by suitable fill. The second alternative would have required the dewatering of the whole site and greatly increased quantities of excavation and filling.

The gain in strength due to consolidation is controlled by the angle of shearing resistance of the soil and by the rate at which the excess pore pressure set up by the imposed stresses is able to dissipate. A detailed site investigation and testing programme indicated that the angle of shearing resistance was adequate, but that in order to ensure a sufficient degree of dissipation of the pore pressure during construction of the dam, the natural drainage should be augmented by a series of vertical sand drains connecting with a drainage blanket placed under the fill on each side of the impervious central core. This modification to the design has been adopted and the construction of the embankment is now completed. The authors point out that measurement of the excess pore pressure, and of the decrease in thickness and gain in undisturbed strength of the foundation strata indicate the effectiveness of this form of foundation treatment.

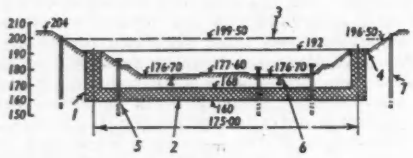
France and North Africa

With Paris as the meeting place for the fifth congress it was not surprising that a particularly strong contribution to the reports and communications was made by French engineers. Many of these papers relate to works which have been described in these columns, at one time or another, giving details of some particular problem or difficulty experienced. For instance, observations of the foundation settlements at Bort dam are described (R.84), and there is an account of the method used to construct an impermeable cut-off beneath the Echelles d'Annibal dam (R.89.) This dam forms the forebay of the Isere-Arc project; there is a depth of 70m of alluvial deposits in the bottom of the valley at the dam site. The investigations of permeability made in this alluvium, and the subsequent constructional problems of the cut-off, are described. The dam itself is carried by a vertical arch, abutting on the rock on each side.

A structure which deserves particular mention is the Gage dam, described by Bellier, Mladyenovitch, Frey and Gautier (C.19), which is considered to have achieved a world record in economy of material. The dam is a thin arch, 38m in height and with a crest length of about 140m; it is situated in the catchment of the Loire, and forms part of a scheme whereby waters from the Issarles lake are to be diverted to the Ardèche, a tributary of the Rhône. The interest of the dam lies in its exceptional slenderness, the mean maximum design stress at the crown being 100kg per square centimetre, about double that for other French designs. The concrete volume of the dam is 4500 cubic metres, about 15 or 20 per cent of that of the corresponding gravity dam. A careful programme of observations of deflections and so on, has been carried out since the reservoir formed by the dam was first filled last summer. It is considered that the dam has behaved very satisfactorily since that time, and the many measurements made will provide more exact knowledge of the rules governing the behaviour of dams of this kind.

Space does not permit the mention here of papers on theoretical studies by French authors, nor of any, save one—the Fessenheim project in Alsace (R.78)—of the interesting achievements in practice described to the congress. It may be recalled that the Grand Canal d'Alsace will comprise a canal for navigation and power built beside the Rhine from the Swiss border to

Strasbourg, with eight power stations along its length. The first two are in operation at Kembs and Ottmarsheim, and the third, at Fessenheim, is now being built. In this area, a marly-limestone rock is found, overlain by alluvium. When Kembs power station was built the bed rock was found at formation level; at Ottmarsheim, it was 30m below ground level, and the excavation for the power station had to be enclosed in steel sheet piling, supplemented by grouting. In the case of Fessenheim power station, however, where the rock is more than 200m below the surface, if a cofferdam sufficiently deep to give stability against "boiling" at formation level had been built, it would still have been necessary to pump out the excavation at the rate of 10 cumecs, which was considered too great a hazard. Thus a foundation problem of unusual scale



1.—Water-tight zone at perimeter of excavation.
2.—Water-tight zone beneath excavation.
3.—Normal level of water table.
4.—Drainage channel for ground water lowering to level 192.
5.—Plugged tubes acting as safety valves to limit uplift pressure (total of seven tubes).
6.—Gauges to indicate upward movement due to grouting.
7.—Pressure measurement.

Excavation for Fessenheim power station, Alsace. The shaded area indicates the impermeable cut-off formed by grouting

and difficulty had to be solved. It was finally decided to construct a horizontal impermeable layer beneath the excavation, in addition to the protection given at the sides.

The power station excavation measured about 175m by 80m. The accompanying longitudinal section gives an idea of the constructional method. The shaded area comprises an impermeable "curtain" of grout. The horizontal screen is 8m thick, and was formed by drilling a grid of holes at 9m spacing and injecting clay grout. The side screens were formed by grouting, with clay and cement grout, from two lines of holes spaced 3m apart, and at 3m centres. The grouting programme took seven months, and consumed 42,000 tonnes of grouting material and needed 22,000m of drilling. The alluvial deposits at this site consist of sand and gravels, with an open structure, and with "lenses" of gravel which allow a free flow of subsoil water. Comprehensive accounts of the subsoil investigation, including, for instance, permeability measurements, are given in the paper. Detailed precautions were taken to measure subsoil pressures and uplift due to grouting; the work was carried out in stages, with elaborate control throughout.

The papers from Algeria, Tunis and Morocco, together form an important section of the congress proceedings, being as numerous as those relating to purely French achievements. These North African studies describe, in some cases, dams of exceptional interest. Generally, they follow—in fact, are part of—the French design tradition, as, of course, French engineers are concerned with them. We have already mentioned the foundations of the Ben Metir dam (R.42 and R.13). The composite dam of Oued Mellègue (R.67) is also noteworthy. This group of papers also includes notes on model studies and reservoir permeability.

United States

One of the American speakers in the discussion on question 17 emphasised the philosophy behind constructional schemes in that country, i.e. that they all had to pay their way. Speed of execution was therefore considered of paramount importance, so that the revenue-earning stage was reached as quickly as possible. That was why, the speaker contended, less emphasis was placed on refinements of design, which tended to take a lot of time. He thought that some of the European works he had seen on the congress tour were ahead of American ones in that respect, but noted that American equipment had been used wherever large quantities of material needed to be handled.

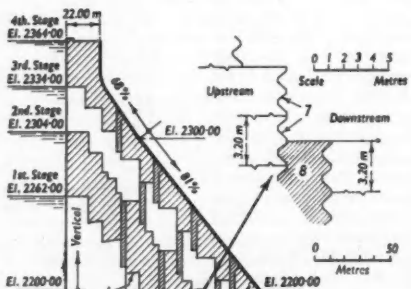
These remarks were, of course, prompted by the subject matter of question 17 as discussed last week. The size and comprehensiveness of American schemes, and their speed of construction, bear out the opinion expressed, but in more general terms there are aspects of design in which the United States engineers have taken the lead. The reduction of cement content noted in question 19 is one example (see paper R.4). Again, the studies of seepage under dams and its control, described in papers R.1 and R.10, are of particular interest.

Garrison dam, now under construction on the Missouri River, is one of the largest earth-fill dams built up to the present; it will embody some 70,000,000 cubic yards of earth-fill when completed. The major structures associated with this dam are founded on clay-shale, a type of formation where substantial foundation movements occur. How the dam and its associated works have been designed to allow for these movements is described by Lane (R.11). "Rebounds" of 2ft have been measured as a result of unloading by excavation, followed by settlements of a few inches as loads are added by structures. The main structures and tunnels have articulated joints, whose design and behaviour are described in the paper. Grout curtains have been situated away from regions where "rebound" might tend to reopen fissures. The behaviour of another dam built on compressible foundations — Fresno dam — is discussed by Daehn (R.7) and Esmiol (R.3).

Switzerland

Swiss papers at the fifth congress included some noteworthy studies in concrete technology (R.96, R.82 and R.37) related to recent large dams in that country. There are also studies on settlements of dams, and a note on the computation of the deflections of the valley sides of the Mauvoisin reservoir under the water load of the reservoir (R.38).

Many of the recent Swiss hydro-electric projects were described in The Engineer last year, and our articles at that time referred to the



1.—Stepped downstream face, first stage.
2.—Typical vertical column of second stage, isolated from other second stage columns by the open slots 5.
3.—Third stage vertical column.
4.—Fourth stage vertical column.
5.—Open slot.
6.—First stage longitudinal joint.
7.—Saw tooth edge for stress transmission.
8.—Detail of slot.
9.—Bed rock.

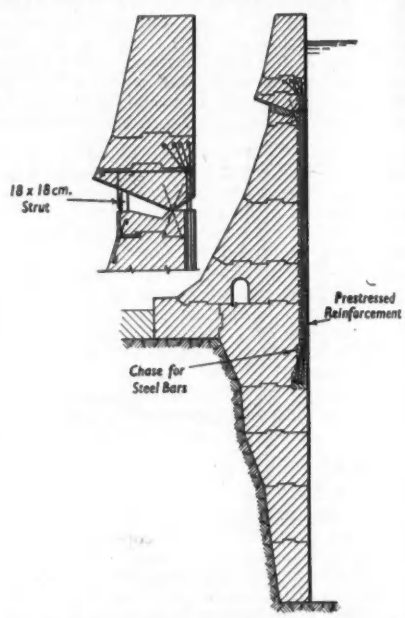
Method of constructing Grande Dixence dam by stages

Grande Dixence scheme in some detail. This large scheme includes the construction of a gravity dam 932ft in height. It is proposed to build the dam in stages, as illustrated in the diagram above, which is taken from communication C.34.

The first stage of construction, up to a height of 594ft, is to be completed with a stepped downstream face. The second stage will be added by constructing a series of blocks, or columns, on these steps. With open slots between the columns, construction can proceed despite varying water levels in the reservoir, but the slots can be filled only when the reservoir is empty, so as to avoid loss of compression in the upstream face. Subsequent stages will be added in the same way. The number and position of the slots was studied by photo-elastic and deformation tests on models, and the best shape for the saw-toothed edges of the joints was also verified from model tests. The slot surfaces are grouted on completion, following the usual practice for grouting contraction joints in a large dam.

Russia

Constructional work on some very large water conservation schemes has been proceeding apace in the U.S.S.R. over the last few years (see The Engineer, March 18, 1955). Four papers were presented at the congress describing this work. The extensive use made of precast concrete slabs for facing work, and the use of prefabrication in forming very large welded cages of reinforcement are described by Sedov



Russian method of prestressing a concrete river wall

and Mikhailov. The use of precast slabs extends to the lining of turbine intakes and draught tubes. A developed view of a scroll casing, divided into a number of standard slab-shapes, is shown in the paper, with a photograph of a completed curved surface of this kind.

Research on temperature stresses in concrete carried out at the Vedeneiev Institute of Applied Hydraulics is described by Bielov. Work on photoelastic and other methods of stress analysis of hydraulic structures at the same Institute is described by Gutman.

The use of prestressed concrete in hydro-electric works, the prestress being applied without the aid of mechanical tensioning devices, is explained by Bassevitch. The diagram above shows one of the examples he quotes. The pivoted block at the top of the wall is allowed to rotate, thus inducing tension in the reinforcement; finally, the hinge is concreted solid, leaving a prestressed and hence an impermeable wall facing the river or canal. The wall shown is 26m in height, and a prestressing force of 187·5 tonnes was applied over a length of wall of 2·5m using ten 36mm diameter steel bars; the latter had an elastic limit of 2500kg per square centimetre, and were tensioned to 2000 kg per square centimetre. The rear face of the pivoted block was allowed to drop 13cm to apply the prestress.

A method of obtaining prestress by pumping cement grout into a cavity in the concrete structure is also described. Another example concerns a lock, built on a compressible sand formation. The invert of the lock is built in two parts, separated by a longitudinal joint. Reinforcement is fixed across the full width of the lock, just above the invert, and concreted

into the base of the lock wall on each side. The lock walls are then built up, and the unequal load thus applied by each half of the structure on the formation below it causes it to settle unevenly, rotating in such a manner as to put a tension in the reinforcement. The latter is then concreted, and finally the longitudinal joint is filled in to give a lock with a prestressed tie at the lower part of the cross section, which assists in taking the hydrostatic loads.

Italy

The recent Italian achievements in the construction of arch dams are now well known, and the congress included several contributions recording contemporary Italian research and development. Semenza gave his views on the safety of different kinds of concrete dams (R.64) and he, also, concluded, in general terms, that arched structures were inherently the more stable. Observations of the deflections of Pieve-di-Cadore dam were recorded by Tonini (C.23 and C.24), and there were reports on Italian model investigations by Oberti (R.71) and Fumagalli (C.26).

The "hollow" gravity dams developed in Italy during the past ten or fifteen years were referred to in discussion by Marcello, who gave some figures for the deflections experienced at Ancipa dam in Sicily, which is the highest structure of this kind yet built; its height is 110m. This speaker also referred to the problem of building a dam on foundations which were compressible, and settled unevenly over the length of the dam. He explained why rock or earth-fill designs were generally selected in such cases, or alternatively the dry masonry dams of Italy, French Africa and Chile could be built. He then went on to outline a novel design suitable for such conditions, one example of which, with a height of 75m, had been built in Sicily. It consisted of a series of concrete blocks, of 4m side, concreted *in situ*, but separated so as to form independent elements capable of relative movement. The joints between the blocks were 20cm in width and were filled with gravel of uniform size (25mm to 35mm), which left a good proportion of voids in the joint. A metallic upstream facing was provided, with joints which gave it sufficient flexibility.

Other Countries

Extensive contributions were also made to the congress by Sweden, Portugal, Germany, Austria and Yugoslavia. The work on model testing of dams at the civil engineering laboratory at Lisbon and studies of the behaviour of dams recently built in Portugal were particularly noteworthy, and it was pointed out that a complete model investigation of a large arch dam project could be carried out in about three months. Several papers were presented by Japanese authors, and there were also papers from Egypt, India, Pakistan, Turkey, Mexico, Spain, Australia and New Zealand.

Business Efficiency Exhibition at Olympia

TO anyone who agrees with the widely voiced complaint that the national effort expended on clerical routines is becoming excessive, the Business Efficiency Exhibition, held at Olympia from June 6th to 16th, must have been a stimulating experience, whether he had in mind the needs of a small firm or a very large organisation. The exhibition, in which over 120 firms participated, had a wide scope, the exhibits ranging from fatigue-reducing office chairs to some of the most recent electronic machines. In what follows only a few items could be selected for description.

Carter Parratt, Ltd.

As shown in the accompanying Fig. 1, the "Vistamatic" visual planning control board shown by this firm is constructed on the unit principle and is made with two to seven panels, each five squares wide by twenty squares deep. These squares are easily and quickly re-positioned to meet changes in planning. Individual lines may be lifted out and placed in a new position. When required, security covers may be fitted. For the signal squares, seven colours are normally available. Besides coloured squares, transparent holders can be fitted which will retain large letters, figures or identity slips, so that at least four different factors can be indicated on any one signal leaf.

Creed and Co., Ltd.

This firm was showing for the first time a facsimile communication system for the transmission of written messages between points connected by telephone wire. This machine, called the "Page Transmitter," takes paper in sizes up to 8½in by 14in (about 1200 typed words) and has a magazine feed for up to 2½ hours' unattended transmission. The messages may be of mixed sizes.

Another machine made by the same firm was a perforating typewriter for punching standard five-unit teleprinter tape from which punched cards for the Powers-Samas and British Tabulating Machine Company's latest accounting equipment can be produced automatically.

Transmission as well as reception of written communications between two points connected by telephone wire is carried out by the "Desk-Fax" facsimile telegraph, using recording paper which needs no special processing and is unaffected by light, temperature or humidity.

Equipment is available for connecting a number of outstations to machines situated at a central office and for communicating a message by a single transmission to a large number of branches there exists a broadcast unit with push-button station selection.

Telephone Rentals, Ltd.

On the stand of this firm was shown a recording instrument for the centralised registration of the production performance of up to twenty production machines. When the machines are operating, detecting contacts fitted on the machines transmit electrical impulses to the recorder, called the "Centralograph," where these impulses produce short horizontal lines on a time-referenced diagram which has twenty divisions, one for each machine. If stoppages occur there are no markings for the machines out of operation. A dial provided at each factory machine enables reasons for stoppages to be reported and recorded on the graph in the form of a code number at the side of the line registration.

Ditto (Britain), Ltd.

Copies at the rate of 120 a minute can be obtained from the hand-operated "C50" spirit duplicating machine shown by Ditto (Britain), Ltd. The fluid can be controlled so as to cut off when running narrow forms, and the machine has a fully visible master attachment for the use of "blockouts" and variable masters. A reversible feed tray permits the automatic feeding of paper sizes from 3in by 5in to 9in by 14in. Three hundred or more copies in up to five colours are obtainable from each master, either consecutively or over a period. An electric version of this machine, the "C51," was also on view.

Addressograph-Multigraph, Ltd.

This firm had on show the "Multilith 1275" tandem model duplicator, which works from masters prepared with pencil or pen, typewriter or any other writing machine, and prints up to 12,000 impressions per hour (6000 double-sided sheets). Copy may be in one or two colours. One operator only is required for this machine, which is illustrated in Fig. 2.

Roneo Neopost, Ltd.

The savings in time which accrue from the use of postal franking machines are well known. Among the equipment shown by Roneo Neopost, Ltd., was a machine in which the same idea is applied to the stamping of National Insurance Cards. The machine can be set up

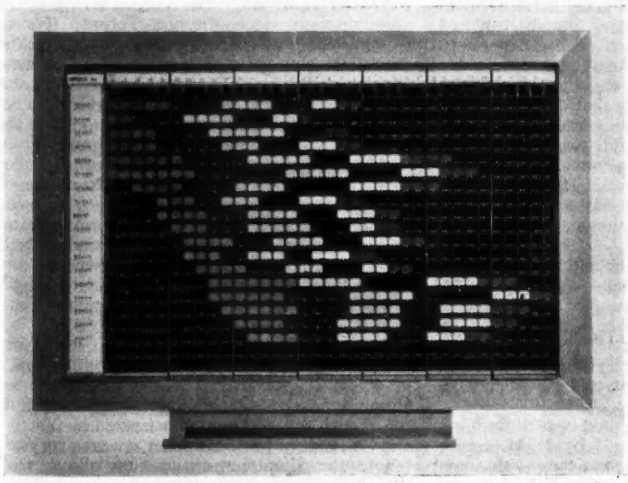


Fig. 1—Seven-panel control board set up for progress planning

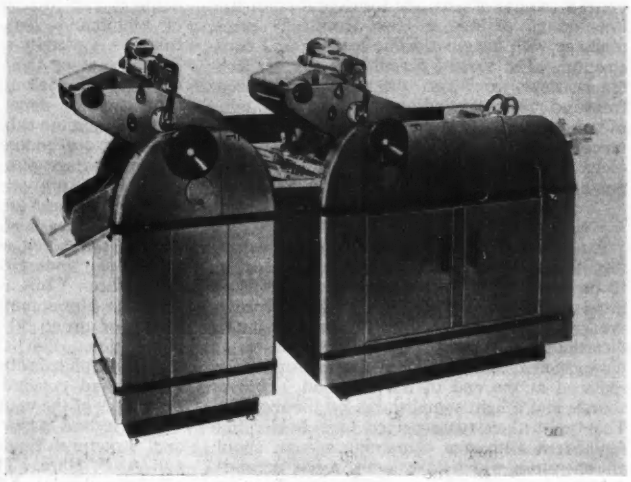


Fig. 2—Tandem duplicating machine

for any rate of contribution, and the checking of purchasers, balance in hand, and reconciliation with wages record is reduced to the simple reading of meters.

A cheque signing machine capable of dealing with 2000 cheques per hour, and a machine for placing facsimile signatures anywhere on a document and operating at 800–1000 per hour, were among other products exhibited by this firm. Both signature machines are provided with counters, and fully protected by Yale locks.

BLOCK AND ANDERSON, LTD.

Among the calculating machines shown by this firm was the "Facit Esa-O," made by Aktiebolaget Åtvidabergs Industrier, Stockholm. This model is an electrically operated 9×8×13 digit machine. Factors as well as operations are readily set with one hand on a keyboard fitted with ten keys.

GESTETNER, LTD.

For the direct production of duplicator stencils, this firm has introduced a stencil camera, which is suitable for copy up to 22½in by 29½in and ½in thick. In addition to flat material, solid objects of small height can also be photographed directly. The complete process is stated to require less than ten minutes. This machine was described in our issue of May 27th.

REMINGTON RAND, LTD.

Our illustration, Fig. 3, shows the Remington Rand front-feed typewriter which was shown for the first time at the Business Efficiency Exhibition. The machine is primarily a typewriter but is equipped with a front-feed mechanism which facilitates the carrying out of all kinds of book-keeping work. Unlike an accounting machine it does not have registers or accumulators

Fig. 3—Typewriter arranged for front feed

to accumulate or extend amounts. The typewriter has three types of front feed. The first permits the use of back-fed forms and automatic line-finding of one or two front-fed forms, together with automatic line-spacing and card-ejection. The second permits the use of back-fed journals and two or more independent front-fed forms including multiple positioning of various forms, for one or more lines of simultaneous posting. The third permits the use of back-fed forms and one front-fed form to a predetermined stop or depth.

HARTLEY ELECTROMOTIVES, LTD.

An automatic system which was shown by this firm allows a battery of tape recorders to be remotely operated by means of controls fitted to the hand-microphones. The recorders are grouped in the typing pool, and incoming dictations are automatically directed to a disengaged machine. When the microphone is replaced at the end of the dictation, a buzzer sounds and a light signal shows on the recorder. The typist then removes the tape holder and replaces it with one containing a new spool, an operation which takes only a few seconds. A monitor enables her to follow the dictation, if required, so that she can change the tape without interrupting the speaker. The machines are equipped with footage indicators—each reel lasts thirty minutes—and an interlocked system of buzzers and lights ensures correct operation.

INTERNATIONAL COIN COUNTING MACHINE CO., LTD.

The "Vee-Three" coin and token counter shown by this firm is stated to count coins of any description at the rate of 2000 per minute. Automatic stops can be set in multiples of five up to 250, in tens up to 500, or in hundreds up to 5000. A five-figure continuous counter and a four-figure continuous reset counter are also fitted. On completion of a count, the friction drive between motor and machines is automatically disconnected, thus making it unnecessary to stop the motor between runs. Attachments are available for making up the coins into rolls.

ARCHIMEDES-DIEHL-MACHINE CO., LTD.

Presentation of statistical data in graphical form is facilitated by the use of this firm's "Vidento" control board. It has sixty-two indicating columns, into which small ball bearings can be dropped to build up to the required height. The balls are contained in a reservoir and can be added one at a time by pressing a button at the top of the column. By pressing a button at the bottom, the balls can be removed in a similar manner a master button being provided for rapid filling or emptying. There is an index by which the columns may be identified, lines across the board divide it into forty-four vertical divisions, each of which holds five balls. The front is of transparent plastic and can be written on with special crayons.

Papers Presented at Aluminium Centenary Exhibition

DURING the period of the Aluminium Centenary Exhibition, which closed on Friday of last week, papers were read and discussions held on a number of subjects relating to the various branches of engineering and the development and expansion of the use of the aluminium alloys in each particular field. A total of six papers was presented, of which short summaries are given below. The first paper was "Electrical Engineering" by C. H. E. Ridpath. A table sets out the properties of "electrical purity" aluminium wire and after stating that the first aluminium overhead transmission line was erected in Scotland in 1896, the paper comments that the lower cost coupled with satisfactory technical properties are responsible for the expanding use of the material for this purpose. There are short notes concerning aluminium, aluminium alloy and steel-cored conductors, the all aluminium conductor being suitable for a 200ft span compared with an actual example of a steel cored aluminium alloy conductor spanning 2200ft. The paper discusses accessories for overhead conductors such as joints, suspension clamps, tappings and vibration dampers and then deals with the various forms of aluminium sheathed and cored insulated cables. A weight reduction of between 50 to 70 per cent of the lead sheathed copper cable is quoted for aluminium sheathed aluminium cable and the paper states that two and four-cored aluminium cables having drawn aluminium sheathing are undergoing full scale tests. Succeeding paragraphs are concerned with gas and oil pressure cables, cables for aircraft, for starter batteries and for bus wiring, flexible welding cables and telephone cables. Concerning the latter mention is made of a 10 mile 54-pair underground line laid by the General Post Office. Coils and windings are referred to and also aluminium busbars for which a cost saving of up to 50 per cent is claimed. The paper notes that the belief that aluminium cannot be jointed satisfactorily is being eradicated rapidly and concludes with a brief survey of other uses of the material.

The second paper presented was "Building and Structural Engineering," by J. M. Smith and A. F. Hare. The paper opens with some of the technical difficulties which had to be overcome before using the aluminium alloys for structural work such as deflection associated with the low modulus of elasticity and the possibility of failure of compression members by torsional or local instability, and then notes a number of successful applications of the material to structures. Those mentioned include: the Dome of Discovery; large span hangers such as that having a span of 217ft, recently completed at Hatfield; telescopic gangways at Southampton and a number of bridges. That section of the paper concerned with building, discusses developments since aluminium sheeting was applied to a church roof in 1897. Various forms of sheets for roof decking are mentioned and particular attention is paid to the use of the material for wall cladding and curtain walling and to surface finish.

T. G. Griffiths, and D. R. Thomas presented the third paper which was entitled "Road Transport." Early development is quoted as having reached its peak in 1920, after which the demand for aluminium fell, due to the reduction in weight effected by flow line production methods. However, the paper states that the use of aluminium is once more increasing to meet the need for reduction in weight to give increased top gear performance, better acceleration, braking and road holding qualities, and gives examples of recent trends. Weight saving resulting from the application of aluminium to passenger service vehicles is broadly treated and figures are given for the weight saved in commercial vehicles together with references to particular classes of vehicles. A section of the paper deals with future prospects and quotes a weight saving of up to 20 per cent for the private car and an improvement in fuel consumption of 16 per cent. Mention is made of the increase in power output by using chromium plated cylinder bores and the fitting of aluminium doors is considered to be logical, while the paper gives consideration to the development of aluminium wheels to give a reduction in unsprung weight. The reduction in weight of a wheel suitable for a 600 × 20 tyre is given at 39 lb. Aluminium trim is considered a possibility and the paper states that the use of aluminium results in a reduction in machining times namely 70 per cent for turning, 60 per cent for milling and 25 per cent for drilling.

"Rail Transport," read by F. L. Stafford, was the title of paper No. 4, which recalls the application of aluminium to the stock for the Liverpool to Southport service in 1905. In 1916 extensive use was made of light metals in the stock for the electrified service between Manchester and Bury. After forty years' service the aluminium components are reported to be in good condition. Between wars, the paper records, aluminium alloy sliding doors and other components were incorporated in the London Underground tube stock and after the second world war several applications were made to coaching stock. These include the ninety "Surface" stock for the London Transport Executive, in each of which there was a weight saving of 6½ tons, and in the paper it is stated that consumption tests have revealed that a 12 per cent saving in energy results from a 14 per cent reduction in weight. The weight saving in the all-aluminium stock for the Toronto Transit Commission is given as 5½ tons per car, while the main line vehicles for the East African Railways are reported to be 4·7 per cent lighter than comparable steel counterparts. Lightweight diesel trains for British Railways are mentioned in the paper and the estimated weight saving is given as 4 tons for power cars and 3·5 tons for trailer cars. The paper considers the future role of aluminium in rail transport and notes the need for higher acceleration and higher braking rates on high-density routes, lighter stock and reduced energy consumption for suburban services and higher speeds for journeys of moderate length, towards the attaining of which aluminium can help by reducing weight.

Paper No. 5, presented by L. M. C. Robinson, was "Aluminium in Marine Applications," in which is recorded the early efforts to use aluminium as a boat building material, such as the French torpedo boat constructed by Yarrow and Co., Ltd., in 1894. However, it was thirty years before the aluminium-magnesium alloys, with their high resistance to corrosion, were produced and the paper mentions that these alloys plus the aluminium-magnesium-silicon groups are

now included in Lloyd's Rules. In the section of the paper dealing with working and fabrication, early jointing problems are mentioned and also that to-day these are largely solved, since rivets up to 1in diameter can be driven while the introduction of "Argonaut" and "Sigma" methods have ensured the production of sound welds. Work on the strength and watertightness of joints has been completed by the British Shipbuilding Research Association, and it is stated that normal shipyard practice can be applied in general to the working of the alloys. Special sections have been developed for marine use, and by using these it is claimed that weight ratios as low as 0·30, compared with steel, can be attained, subject to greater deflection being permissible. A few pointers are given regarding economics applied to aluminium applications and mention is made of sidelights, lifeboats, steam heating coils for oil tanks, and the increase in deadweight together with savings in maintenance charges. The liner "United States" is quoted as an example of large-scale application of the aluminium alloys, and by their use it is stated that a weight saving of 15 to 20 per cent was effected, allied with a reduction in fuel consumption of about 9 per cent or £100,000 per annum.

"Aluminium in Packaging," given by J. A. Ambler, was the title of the last paper in the series presented during the exhibition. The paper comments upon the development of the packaging industry and that it uses 25,000 tons of aluminium annually. Aluminium foil is impermeable to air, moisture and oils and completely opaque and widely used for packaging, and the many applications and current developments, particularly in the food industry, are mentioned. Over 50 per cent of collapsible tubes are of aluminium and several products are listed as being suitable for the wider employment of the material. The paper deals with rigid containers and closures and notes the wide applications of seamless impact extruded containers in a number of industries, especially where the contents are under pressure. Reference is made to the extensive use of shallow drawn cans in Norway, Sweden and Denmark, and to the expanding use of aluminium for non-expendable containers for shipping acetic acid, pectin and detergents, and the development of such items as beer barrels and milk churns.

Technological Irradiation Group, Harwell

As a step towards helping industry make full use of the large supplies of radioactive materials which will become available from the expanding atomic energy programme, the United Kingdom Atomic Energy Authority has formed a new Group at Harwell. Known as the Technological Irradiation Group, it will carry out research on the uses of radiation and will be able also to place at the disposal of industry equipment and materials for the same purpose. This new development is a result of the fact that stocks of fission products have already accumulated and will increase considerably as the British power programme is put into effect. Radiation hundreds of times greater than the total amount of radium in the world will be available and can be turned to useful purposes. Besides fission products the group will make use of Van de Graaf machines and very strong sources of radioactive isotopes which will be produced in new reactors now being built at Harwell. The following notes have been prepared to explain the objects of the new group and to outline some of the developments which may be expected.

When the nucleus of a uranium atom undergoes fission in a nuclear reactor the two large fragments into which the nucleus is split are radioactive. The radiations from these radioactive uranium fission products can be used for many purposes in industry and medicine. Stocks of fission products have already been produced by the nuclear reactors at Windscale. As the British programme for producing power from nuclear energy is implemented, there will be available for useful purposes radiation hundreds of times greater than that available from the total amount of radium in the world. One way of utilising the radiation from fission products is to use, without any processing, fuel rods which have been withdrawn from the reactor. Normally these fuel elements are stored for a time to allow some of the radiation to die away. During this storage period they can be used as radiation sources. After this storage period the fuel elements are processed to recover the original uranium and the plutonium produced from it while it is in the reactor. Residual liquors from this process contain the fission products. These can be evaporated and the "gross fission products" used as a source of radiation. For some purposes it may be preferable to isolate individual fission products such as caesium 137 from the gross fission products.

The form in which the fission products will be used will depend on the requirements of each individual application and will be chosen bearing in mind the cost, the maximum size of source permissible, and the half-life of the fission products. Whatever form is used the effects of the radiation are unaltered. It has already been found that the radiations can effect polythene to make it more resistant to heat (polythene is a plastic widely used to make unbreakable bowls and buckets). This modification of polythene would be of particular interest in its application in the manufacture of special cables where its resistance to heat would enable it to be used at higher ratings and at higher temperatures. Radiation can also be used to vulcanise rubbers: this is particularly effective in the case of the rubbers made from silicone. The use of radiation also enables the vulcanisation procedure which may require several hours for completion to be speeded up considerably.

In the chemical industry it has been found that processes which require high temperatures and pressures have, when used in conjunction with radiation, taken place under less onerous conditions with a corresponding saving in plant costs. In addition, by using radiation, it has been found possible to produce many plastics which could not be made by conventional methods. Chemical processes can often be speeded up if radiation is used, for example, in the preparation of the insecticide "gammexane." In the manufacture of expensive drugs such as hormones, radiation has also many potentialities. Among the physical effects produced by radiation is the improvement of the properties of transisters.

The radiation from fission products can also be used to sterilise materials; this sterilisation does not involve any significant rise in temperature and so offers considerable advantages. There is therefore an obvious future for the use of radiation in the sterilisation of pharmaceuticals including antibiotics such as penicillin and streptomycin where heating is not permissible. Fresh vegetables and meat have also been sterilised in this way. Small amounts of radiation prevent potatoes from shooting and enable them to be kept in good condition all the year round. It is possible that widespread use of radiation sterilisation may bring about the reduction, or maybe even the elimination, of the necessity for refrigeration to keep food fresh.

As has already been mentioned, separated fission products such as caesium 137 have particular applications, for example compact sources of caesium equivalent in strength to thousands of grammes of radium are envisaged for use in hospitals, the radiations from these large sources of caesium being used in place of the radiation from radium or large X-ray machines in the treatment of disease. Another possible use of radiations is to sterilise bone required for transplanting, this would enable a bone bank to be set up. Likewise, sections of artery required for grafting could also be preserved for subsequent use by means of radiation.

Among the possible applications in agriculture is the use of radiation to induce mutations in seeds to produce new species of plants such as barley with short stalks or other desirable qualities. Spore activity may also be reduced by radiation and so excessive respiration in cereals could be prevented. It may also be possible to use radiation to kill off insect pests in materials such as grain.

The study of the uses of radiation on an industrial scale is only in its infancy, but sufficient is known to indicate that it will be a tool of considerable power. The Technological Irradiation Group at Harwell will be equipped with very large fission product and radiation sources, machines capable of accelerating particles of energies of millions of volts, such as the Van de Graaf, and the linear accelerator. This equipment will be available to help industry pursue research on the uses of radiation. The new group will not only be able to do all the necessary irradiations for industry but will also give advice to industrialists and scientists in industry on possible radiation applications which would benefit industry. Irradiation cells which are now being built are the biggest of their kind in Europe and will enable this group to make any foreseeable irradiations necessary. It is hoped that industry will make much use of these new facilities.

Newcomen Society's Summer Meeting

THE Society held its summer meeting in Newcastle upon Tyne under the presidency of Mr. Rex Wailes, M.I.Mech.E., from June 7th to 10th; this was its second visit, the first having been made in 1935. This area was chosen again for its early railway associations and because the few remaining steam winding engines will soon be scrapped. On the evening of June 7th members went by invitation of Dr. C. I. C. Bosanquet to the Stephenson Building, University of Durham, where they examined working exhibits and drawings before hearing a stimulating address entitled "Teaching the History of Mechanical Engineering to University Students," by Dr. A. F. Burstall, M.I.Mech.E., Professor of Mechanical Engineering and director of the Stephenson Engineering Laboratory.

On June 8th members visited the pumping station of the Sunderland and South Shields Water Company at Ryhope, where Mr. A. G. McLellan, M.I.C.E., engineer and general manager, explained the working of the two large 60 h.p. beam pumping engines made by R. and C. Hawthorn in 1868. Both are compound, double-acting, rotative engines with pump rods at both ends of the 33ft beams. One engine was working at 6 r.p.m. and members were greatly impressed by its smooth and silent running and with the beautiful condition in which both engines are maintained.

The party then drove to Warden Law Colliery to see the single-cylinder beam hauling engine, built by Murray of Chester-le-Street in 1836, still working the inclined railway at Hetton le Hole, laid down by George Stephenson in 1822. The engine has a loose eccentric reversing gear and drives two drums 8ft diameter. It hauls up a gradient of 1 in 19 a set of five loaded 12-ton wagons out of the mine, partly balanced by the empty set descending on the other track, the length of run being 760 yards. The loaded trucks then travel by gravity to Sunderland down a system of four self-acting inclines and pull up the empty trucks by wire ropes. Members were intrigued by the two tracks using three rails only, except for a loop with four rails to allow the trucks to pass. Mr. W. L. Tulip, of the National Coal Board acted as guide here and at Elemore Colliery, where the party inspected a very old single-cylinder, vertical winding engine, "Isabella," with 39in diameter cylinder and 6ft stroke. She ran at 30 r.p.m. and drove the drum 15ft 10in diameter and the flywheel 23ft 9in diameter forming the brake path, the winding depth being 600ft. The engine was supported on a large A-frame of massive timber baulks, and it was a new experience for members to hear and feel the strains in the wood when the engine was winding up the three-deck cage. Nearby, "Elemore Lady" winding engine, made by Davy Brothers, Sheffield, in about 1870, was working. This is a double-cylinder, vertical engine, 42in diameter by 5ft stroke, winding a four-deck cage from 900ft depth.

The motor coaches stopped at St. Peter's Church, Monkwearmouth, Sunderland, to enable members to see the Saxon stone pilasters or portions of circular pillars, well preserved as exhibits. The surfaces appear to be "turned," but how it was done caused much speculation. This church is said to be one of the first three

stone churches built in Britain. After tea at Durham Castle, by invitation of Sir James Duff, Warden of the Durham Colleges, members divided into two parties, one being shown round the Cathedral and the other over the castle. The day ended with a civic reception given by the Lord Mayor of Newcastle upon Tyne, Alderman H. Waller, at the Mansion House.

On Thursday, June 9th, members visited the Museum of Science and Engineering on Town Moor and were pleased to see the bronze mural tablet to the memory of Captain E. W. Swan, a former vice-president of the Newcomen Society, and the first hon. curator of the Museum from 1934 till his death in 1948, who was responsible for its organisation. The museum contains several thousands of interesting historical exhibits but needs far more space to show them effectively. It is particularly rich in marine and electrical engineering, shipping, mining and early railway transport, also numerous examples of the inventive genius of Sir Charles Parsons, the private workshop of Mr. J. H. Holmes, and other exhibits of North-East Coast industries.

The party had lunch at the Heaton Works of C. A. Parsons and Co., Ltd., by kind invitation of the chairman, Sir Claude Gibb, F.R.S., after being shown round the steam turbine and machine shops, and the museum, in the entrance hall of the modern offices, containing many original pieces of Parsons's experimental apparatus.

As this day was the 174th anniversary of the birth of George Stephenson on June 9, 1781, members were able to pay tribute to his memory at his birthplace at Wylam and at Dial Cottage, where he lived when he was engineman at Killingworth Colliery. Both cottages bear memorial tablets to this famous railway engineer. A visit was also made to Causey Arch at Tanfield, built by Ralph Wood in 1727. This is the oldest surviving railroad bridge in the world and Mr. Chas. E. Lee, vice-president, gave a short talk on its history. The top of the single stone arch of 103ft span is now a pathway. The annual dinner was held in the evening at the Royal Station Hotel and was attended by the Lord Mayor, several distinguished guests and Dr. and Mrs. Charles Penrose, of U.S.A. Afterwards, Mr. M. W. Flinn (member) gave an interesting lecture, appropriately entitled "Technology and Industry in the Derwent Valley in the Eighteenth Century."

On June 10th, the party went to Chollerford to see the remains of Hadrian's Wall, built between the Tyne and Solway about A.D. 122. Dr. Ian Richmond, Professor of Roman Archæology at Durham University, gave a lucid talk on the masonry remains of the Roman Bridge abutment at Chesters, where a Roman watermill probably existed also. Moving later to the remains of the Roman Fort at Housesteads, which are remarkably well preserved, Professor Richmond gave to the party a vivid description of the occupation of the fort by the Romans, and the uses of the various parts of the building, which can still be traced by their foundations.

In the evening, members attended a conversazione given by the North-East Coast Institution of Engineers and Shipbuilders, at which Mr. Mungo Campbell, past-president of the Institution, deputised for the president, Mr. P. L. Jones. In spite of transport difficulties due to the railway strike, the summer meeting was attended by about sixty members and was voted one of the most successful in the history of the Society, chiefly due to the thorough preparatory work of Professor Burstall and the honorary secretary, Mr. A. S. Crosley.

Book of Reference

Metal Industry Handbook and Directory. London: The Louis Cassier Company, Ltd., Dorset House, Stamford Street, S.E.1. Price 15s.—This handbook and directory, now in its forty-fourth year of publication, provides a standard work of reference and a comprehensive source of information for all those connected with the non-ferrous metal industries. Up-to-date information is given on the properties of the newer as well as the more familiar metals, and an extensive section is devoted to summaries of British Standard, Aircraft Material, D.T.D., and Admiralty specifications. The handbook also includes a section on the chief metal finishing processes and data regarding all the common rod, bar, sheet and strip products. Two additions to the book are standard classifications of non-ferrous scrap and a list of trade names.

Twin Screw Steam Tug "Barana"

LAST month trials were completed of the twin screw steam tug "Barana," illustrated herewith, which has been built by John I. Thornycroft and Co., Ltd., to the order of the Crown Agents for Overseas Governments and Administrations on behalf of the Government of Ceylon. The tug, which meets the requirements of Lloyd's Register for towing purposes, is designed for duties in Colombo harbour and will be engaged mainly in berthing and unberthing large seagoing ships. Although essentially a harbour tug, the vessel is a good sea boat and is able to proceed to Colombo under her own power. She has the following dimensions: length overall, 122ft 6in; length between perpendiculars, 115ft; breadth moulded 31ft 6in; depth moulded 14ft 6in; draught maximum 13ft, and gross tonnage approximately 350 tons. The maximum speed running free is 13·04 knots and the maximum static towing pull is 22 tons.

Accommodation for the officers is arranged on a flat forward of the boiler-room and immediately forward of the boiler casing, in the house on the main deck, and includes cabins for mate, chief engineer, second engineer below deck, with the galley, pantry, saloon and captain's cabin in the deckhouse. Two single-berth cabins, crews' wash and entrance are in the deckhouse placed aft of the engine-room skylight, while the main accommodation for the crew is arranged below deck, aft of the engine-room, and has bunks for fourteen men. The top of the forward house forms the bridge deck and the navigating bridge deck, which is fitted with a permanent double canvas awning, is raised 4ft above the bridge deck. Single portable awnings are provided over the bridge and main decks and, since the ship has to work in a tropical climate, the accommodation and engine and boiler-rooms are mechanically ventilated and also have adequate natural ventilation. Hastie and Co., Ltd., has manufactured the steam and hand steering gear, which is housed in the aft deckhouse, and Clarke, Chapman and Co., Ltd., has supplied the steam and hand windlass and the double-geared steam capstan which is mounted aft. Other equipment includes a Merryweather fire pump which can throw a single jet of water of 1½in diameter to a height of 185ft and is also capable of delivering 800 gallons of water per minute at reduced pressure. A 3in monitor is mounted forward of the bridge deck and fire-fighting equipment includes one forward fire delivery head, two aft fire delivery heads, and a "Foamite" continuous foam generator capable of producing 500 gallons of foam per minute with a water pressure of 40 lb per square inch.

Propulsion is by two screws, each driven by a Thornycroft triple expansion, surface condensing, reciprocating steam engine having cylinders of 13½in by 21½in by 35in diameter and a stroke of 27in. The engines develop a total of 1564 i.h.p. at 138 r.p.m. and are supplied with saturated steam by two single-ended Scotch cylindrical marine return tubes, oil-fired, hot air forced draught boilers, having a working pressure of 200 lb per square inch. One duplex oil fuel pumping and heating unit is installed and there are two Weir 3in by 4in by 6in vertical oil fuel pumps, one of which can be used as standby to the oil fuel transfer pump. This unit, rated at 10 tons per hour, has a diameter of 5in and is steam-driven, the engine having a cylinder of 4½in diameter by 12in stroke. The capacity of each oil fuel pump and heater is 2000 lb of oil per hour and there is also one set of hand-operated fuel lighting-up equipment. James Howden and Co., Ltd., provided the forced draught, centrifugal, double inlet fan, rated to deliver 9000 cubic feet of free air per minute against 2½in water gauge at 650 r.p.m. and direct-coupled to two enclosed forced lubricated steam engines, one of which acts as a standby. The fan discharges through air heaters by means of trunking fitted with air distribution swing valves so that the air can be delivered to either boiler or both.

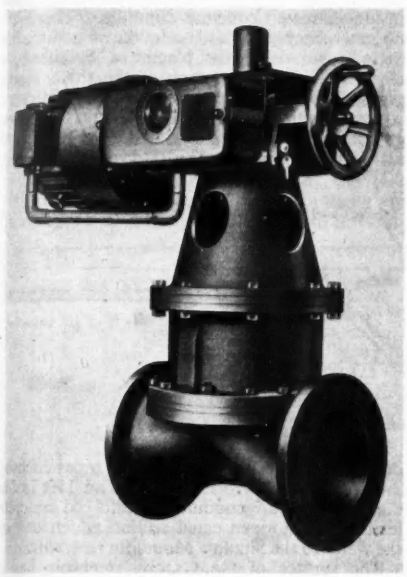
Twin screw steam tug "Barana"

There is one main, four-flow, regenerative condenser and a Drysdale 1600 gallons per minute centrifugal condenser circulating water pump directly coupled to a "Thermall" enclosed, forced lubricated, steam engine. The other auxiliaries have been supplied by G. and J. Weir, Ltd., and consist of main and auxiliary feed pumps, each having a capacity of 26,500 lb per hour and suctions from the combined hotwell and feed tank, reserve feed tanks, sea and boilers for circulating. The pumps are of 6in diameter and the steam cylinders have a diameter and stroke of 8½in by 18in. A 19in diameter "Monotype" air pump is fitted and is rated to handle 26,500 lb of condensate per hour, the vacuum being 25in with a circulating water inlet temperature of 85 deg. Fah. Twenty-six tons per hour against a discharge pressure of 100 lb per square inch is the capacity of the general service pump and the bilge and ballast pump can deliver 27 tons per hour when on bilge duty and 40 tons per hour when doing ballast duty while the fresh water pump has a rating of 8 tons per hour.

The oil fuel tanks, which are sited between the engine and boiler-rooms, have a capacity of 67 tons and a total of 34·8 tons of feed water is carried, 23·8 tons in the double-bottom tank in the engine-room and 11 tons in a tank to starboard forward of the boiler-room. The electric power requirements of the ship are met by a steam-driven, 12½kW, 110V d.c. generator mounted in the engine-room.

Electrically-Actuated Diaphragm Valve

THE accompanying illustration shows an electrically operated diaphragm valve manufactured by Saunders Valve Company, Ltd., Cwmbran, Mon. The valve is made in five sizes, from 6in to 12in, suitable for line pressures of 100 lb to 25 lb per square inch. As in the case of the firm's handwheel valves, a range of body materials and diaphragm grades is available. A totally enclosed, drip-proof, 2 h.p. motor is fitted which drives the valve spindle through oil-lubricated worm gearing. The drive is reversible at any position of the valve, and normally is arranged to give a brief delay between the starting of the motor and the beginning of valve travel, although units with quick valve response can be supplied if required. A mechanical indicator shows the valve position reached which is controlled in the "open" position by a limit switch, and in the "closed" position by a torque-operated microswitch. This torque control is adjusted to suit the line pressure and prevents stalling the motor should an obstruction make it impossible to close the valve fully.



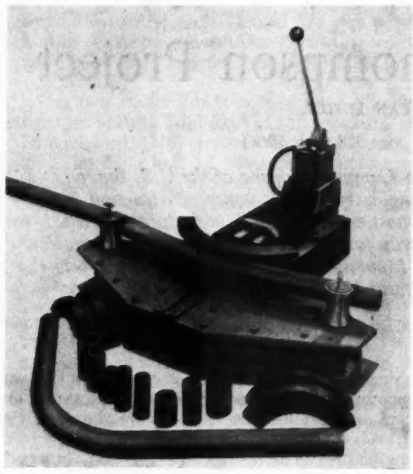
8in diaphragm valve with electrical actuator. A handwheel is provided for emergencies

The emergency handwheel is provided with electrical and mechanical interlocks to safeguard against operating it simultaneously with the motor. In the standard version, provision is made for operation on 400V, three-phase, 50 c/s, a separate 230V, single-phase supply being used for the limit switches. Either local or remote control is possible and, if required, the remote control panel can be fitted with indicator lights or a dial indicator showing the actual valve position.

Tube Bending Machines

PARTICULARS have been received from Tubela Engineering, Ltd., 6, Furze Street, London, E.3. of some new hydraulically operated tube bending machines which the firm has introduced. A prototype of the hand-operated model of three new heavy-duty machines is illustrated herewith.

This machine is designed to bend pipes from 2in to 4in diameter and has bending centres from 2ft 9in to 5ft, its ram stroke being 20in and imparting a bending load of 17 tons. The rigid frame of the machine is built up of heavy steel upper and lower plates reinforced at the end pin location points and braced together by 7in by 3in rolled steel channel. Steel channel of similar section forms the centre beam upon which the hydraulic rams and pump are mounted. The machine illustrated is fitted with twin single-acting rams and return springs, but



Hand-operated heavy-duty hydraulic tube bending machine

production models will have double-acting rams. The hydraulic system has a working pressure of 5000 lb per square inch and through a selector lever the number of pump pistons operated on the working stroke can be chosen to vary the speed of ram movement.

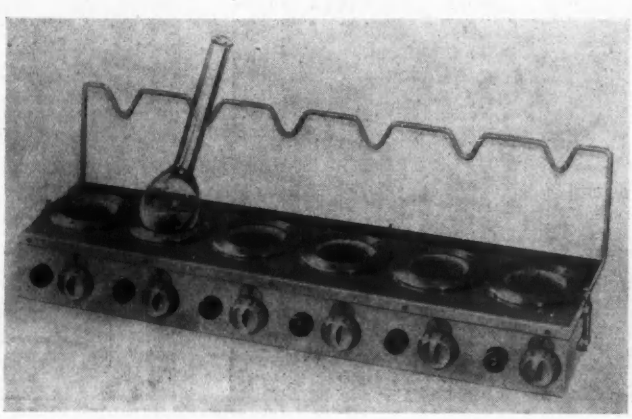
On an alternative model of this machine a motor-driven hydraulic pump is fitted and ram movement is controlled by a forward and reverse valve. The third model of the machine is also fitted with a motor-driven pump, but is designed to deal with heavier or larger pipes requiring a bending load of up to 27–30 tons.

The cast steel standard formers supplied with the machines are for nominal bores of 2in, 2½in, 3in, 4in and 5in, the four first mentioned sizes being suitable for bending up to 90 deg. in one operation. When using the short 5in former on the heaviest duty machine, the pipe is moved across the winghead after each bend of 15–20 deg. until the desired angle is obtained.

A new 2in capacity hand-operated hydraulic tube bender also being made by the firm has a winghead with pin positions for six pipe sizes. It bends tubes to a nominal angle of 90 deg. or 120 deg. with an extension ram. The lever operated hydraulic unit for the double-acting ram also has a selector by which the bending and ram-return speeds can be varied.

Laboratory Heaters for Kjeldahl and Soxhlet Tests

ELECTRIC heating apparatus for use in the Kjeldahl, Soxhlet and similar tests is being manufactured by Electrothermal Engineering, Ltd., 270, Neville Road, London, E.7. Our illustration shows a macro-Kjeldahl unit. These units consist of an aluminium casing fitted with two or six heaters totalling 200W to 2100W, and suitable for flasks of 30 to 800 millilitres. By virtue of the flexibly constructed heating mantles close and even contact is maintained with the flask which can vary substantially from the nominal size. Inside the casing a packing of glass wool reduces the heat loss, and energy controllers, which are supplied for a.c. mains operation only, serve to control the temperature. In the two-flask version, there is only a single controller for both heaters, but individual on-off switches and pilot lamps are provided. The larger unit has separately controllable heaters, also equipped with pilot lamps. Rubber feet under the casing protect the bench, and as the illustration shows, the ends are fitted with clamps for flask supports or for fitting to existing stands. Three and six-flask units similar in design, but differing in flask capacity, wattage, and the number of controllers provided, are available for distillation and extraction purposes. A six-position macro-Kjeldahl set for 18 to 50 millilitre flasks is also being made; this has a casing made of acid-resisting asbestos cement panels.



Macro-Kjeldahl heater unit showing pilot lamps and on-off energy controls

Precision Wire-Wound Resistors

STABILITY to ±0·1 per cent for operation between −60 deg. and +105 deg. Cent. is claimed for a range of wire-wound resistors manufactured by Electrothermal Engineering, Ltd., 270, Neville Road, London, E.7. These resistors, which are being marketed under the name "Precistor," are made in six ranges covering 0·1 ohm to 1 megohm, and are intended for use in electronic circuits and as meter shunts. They are wound on low-loss plastic formers, in a manner to give the minimum of inductance and self-capacitance, and are given a gas and moisture-proof seal. Adjusted to within ±0·1 per cent (for 10 ohms to 1 megohm), the windings have a temperature coefficient of 0·002 per cent per degree Centigrade, and can be supplied in matched sets, and with a variety of terminals and tappings if desired. Standard resistors are rated at 2W, but higher ratings up to 10W can be supplied. In addition to the normal cylindrical form, card resistors of from 1 to 200 ohms are also manufactured, while a special design for computors is available with resistances of up to 3 megohms and over.

Sub-Micronic Air Filter

AN air filter claimed to have an initial penetration of less than 0·05 per cent, as shown by the methylene blue or di-octyl phthalate test, has been put on the market by Vokes, Ltd., Henley Park, Guildford, Surrey. This filter, called the Vokes 55 "Absolute" air filter, is made from esparto grass paper, containing finely carded long asbestos fibres, folded into panels of 24in by 24in or 8in by 8in size, and varying depths, and resin-bonded into a wooden frame. Each element has a uni-cellular sponge rubber seal which locates against the assembly framework, thus allowing easy removal of contaminated panels. Where required, as, for instance, with radioactive dust, this may be done without direct handling, and disposal by burning can be carried out without any difficulty arising from the small amount of asbestos present. The thinness of the paper allows a very large area to be accommodated in a small space, and it is claimed that in consequence the 24in by 24in by 5¾in unit can be rated at 500 cubic feet per minute for an initial flow restriction of 1·0in water gauge. As is the case with all purely mechanical filters, as opposed to those in which electrostatic action plays a part, the efficiency of retention rises steadily as dust accumulates.

Colorado - Big Thompson Project

BY OUR AMERICAN EDITOR

No. III—(*Continued from page* 828, *June* 10*th*)

For the past fifteen years the Colorado - Big Thompson scheme of the U.S. Bureau of Reclamation has been the major civil engineering work under construction in Northern Colorado. The scheme is now almost completed and, in fact, functioned last summer to save irrigated lands from crop failure due to drought. It gathers waters on the western slope of the Rocky Mountains and diverts them through a 13-mile long tunnel underneath the Continental Divide to the eastern slope, there supplementing the irrigation water supply. The potential of the water is used in several power stations to generate approximately 600 million kWh annually.

Granby Pumping Plant

THE Granby pumping plant is the third largest pumping station to be built by the Bureau of Reclamation and may be considered as the heart of the Colorado - Big Thompson project. The plant is situated on the north shore of the Granby reservoir, about 5 miles north-east of the town of Granby, Colorado. It uses three pumps to lift nearly all the water diverted to the eastern slope from the Granby reservoir to the Granby pump canal for flow to the Shadow Mountain reservoir. The Granby reservoir, which was formed by the construction of one earth and rock-fill dam and four dykes, has a total storage capacity of 544,900 acre-feet, of which 467,500 acre-feet is active capacity for operation of the plant. Because this pumping plant is such an extremely important link in the Colorado - Big Thompson scheme, the plant was designed to provide the highest degree of reliability. From the initial pump intake in the reservoir to the final discharge into the canal, a unit system has been employed to ensure that a stoppage of any one of the water passages will not hamper the output of the remaining pumps.

Due to the geological conditions at the site of the pumping plant, concern was felt from the outset that the slopes planned for the excavation would have to be very flat for reasons of stability. Laboratory tests indicated, however, that 1 : 1 slopes would be sufficiently stable. It was recommended that a 10ft berm be excavated on top of the silt-stone and the overlying glacial gravels be cut back on about a 1½ : 1 slope from the berm. This berm was omitted, however, during initial construction operations until it was found that the continual ravelling of the glacial overburden material endangered the workmen in the cut below ; the berm was then constructed as originally planned and further troubles from this cause were not experienced. During excavation, faults were exposed in the walls. There was a severe fault on both the left and right excavation walls. It was concluded that these faults could cause some slides and result in over-excavation. All three slides were due to the existence of fault zones and lubrication from ground water.

It was also found that the silt-stone at the site was quite susceptible to deterioration by moisture because of the silt-clay cementing material used. If water was allowed to collect on the floor of the excavation, and subsequently trucks and other equipment worked upon this wet surface, the silt-stone was turned into a mud slurry which soon became impassable. It became necessary, therefore, to keep the floor of the excavation well drained to permit mobility of the excavation equipment. This difficulty also verified earlier conclusions that the newly-exposed surfaces of the silt-stone at final grade should be protected with some lining to prevent spalling and deterioration before placement of the concrete. Thus, when the final grade was achieved, the walls and floor were coated with an asphalt emulsion. This treatment was only partially successful, as the emulsion was placed after some spalling had occurred, thus preventing a good bond with the rock.

As shown in the accompanying illustrations, the pumping plant structure contains three pumping units. Each unit consists of a single-stage, vertical-shaft, double-volute, centrifugal pump which discharges 200 cusecs at a rated head of 186ft and at a speed of 327 r.p.m. The pumps are driven by 6·6kV, three-phase, 60 c/s, 6000 h.p. synchronous motors, and each unit is provided with hydraulically-operated butterfly valves on the intake and discharge sides. These valves allow each unit to be inspected and repaired without interfering with the operation of the other units. The intake structure of the plant is semi-circular in plan and leads to three 7ft 3in inside diameter concrete conduits. There are no emergency gates at the intake structure, but there is provision for placing a bulkhead to close the entrance to each of the three intake pipes. The intake conduits are of reinforced concrete with wall thicknesses increasing from 18in near the intake to 27in under the maximum fill near the pumps. The three discharge conduits are 87in inside diameter steel pipes encased in concrete. They discharge into an 11ft inside diameter pressure conduit of reinforced concrete leading to the open canal section which carries the water to the Shadow Mountain reservoir.

The surface of the Granby reservoir has a maximum fluctuation of 94ft ; therefore, the pumping plant has a greater vertical height than would be required in a plant of the same capacity with a normal forebay fluctuation. The final yard elevation is 22ft above the natural ground surface and 7ft above the maximum water surface of the Granby reservoir. The sub-structure extends 133ft below the yard to provide adequate submergence for the pumps at the minimum water surface elevation in the reservoir. The superstructure contains a machine shop, which

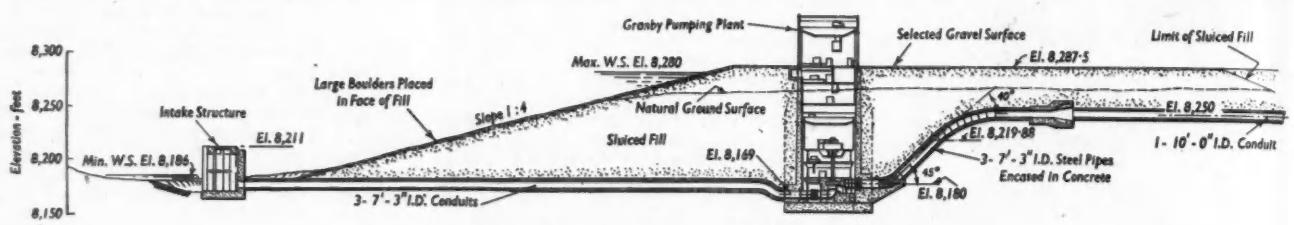


Fig. 6—Sectional elevation on the centre line of Granby pumping station

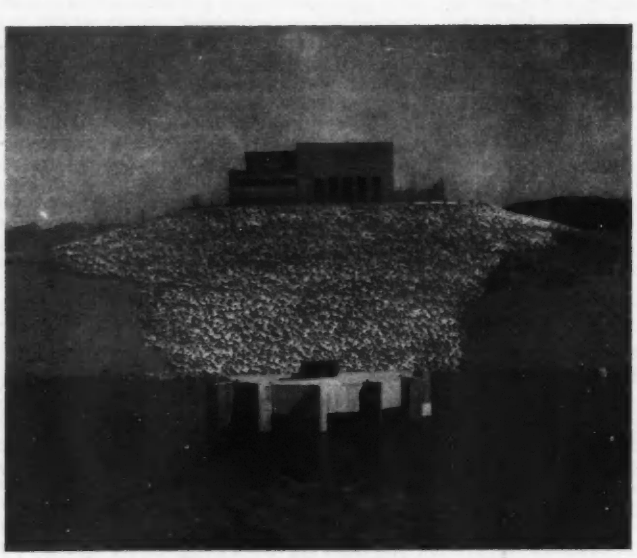


Fig. 7—The Granby pumping plant with intake structure in the foreground

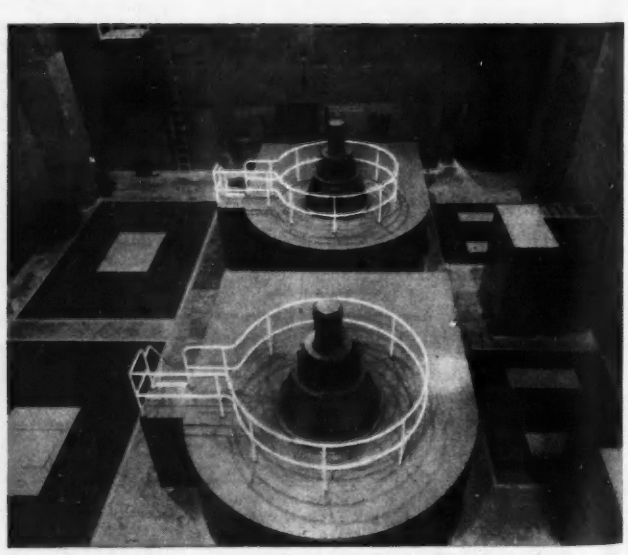


Fig. 8—Interior of the Granby pumping plant showing two of the three 6000 h.p. motors

has a 50-ton overhead travelling crane, a control room, battery and switchgear rooms, and operator's facilities. Cable spreading, oil storage and oil purification, air compressor facilities, and dewatering pumps are on the first floor below yard level. The motor room is provided with a 25-ton crane for handling all equipment after it is lowered to that level by the machine shop crane. A 12½-ton crane for handling the pump impeller and the intermediate shaft may be moved from one pump bay to another by the motor room crane. The sump and dewatering facilities are situated at one end of the substructure and the cable shaft, elevator shaft and stair well at the other end.

While the superstructure of the pumping station presented no unusual design difficulties, the substructure offered major design problems because of its great depth below ground. As shown in an accompanying drawing, the substructure is cellular in construction and consists of four main elements : the base slab, the semi-circular ends or arches, the longitudinal exterior walls, and the cross walls and buttresses. The cross walls and buttresses combine to serve as diaphragms or transverse plates to prevent the base slab and longitudinal walls from deflecting inward. Early studies indicated that the semi-circular ends were a natural solution for this layout. The hydrostatic loading places them in direct compression and this increases their watertightness. Furthermore, since the loads are carried in a horizontal direction, major concentrations of moment and thrust are not introduced into the base slab, as would have been the case if buttresses had been used on the end walls. As indicated in the sectional elevation (Fig. 6) these semi-circular ends were increased in thickness for a short distance above the base slab to resist the local bending stresses at the junction of the base and the arches. All the floor slabs up to and including the one at elevation 8252·50 were separated from the longitudinal exterior walls and the semi-circular ends by a 1in expansion joint. This separation ensured that the exterior walls spanned in a horizontal direction. The longitudinal exterior walls were increased in thickness with depth to resist the horizontal loading acting normal to them.

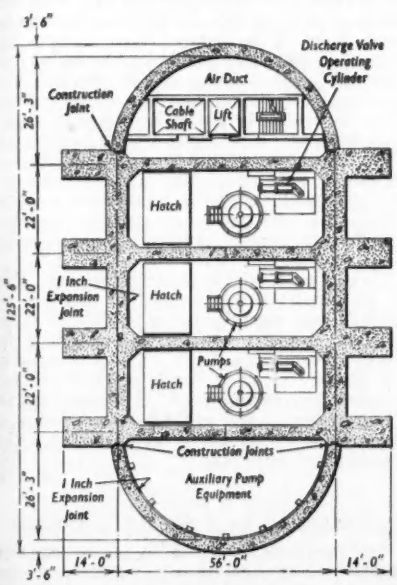


Fig. 9—Plan of the Granby pumping plant at pump floor level

The transverse plates are the major structural elements in the substructure and are 133ft high and 84ft wide. Each plate has an opening 50ft wide and 33ft high at the motor room and a second opening 28ft wide and 11ft high near the top. The expense of installing an exterior four-ply waterproofing membrane was eliminated by taking precautions to minimise shrinkage cracks. In the first instance the base slab and the walls up to the motor floor were cooled after the concrete placement by circulating water through a system of piping similar to that used in concrete dams. Secondly, each vertical lift was poured in four separate placements consisting of the two arches and then the two connecting longitudinal walls.

The two major loads acting upon the substructure are the dead load of the structure, and the equivalent fluid pressure from the saturated fill. The dead load of the entire structure was assumed to be distributed down through the exterior walls, the arches and transverse plates to the foundation as a uniform load. The equivalent fluid pressure of the saturated fill was taken at 85 lb per square foot per foot of depth. This value was used because the backfill was to be sluiced into place and would subsequently be submerged. In addition, it was felt that a relatively rapid fluctuation of the Granby reservoir could cause a 10ft difference in the hydraulic gradient, or saturation level, between the two longitudinal exterior walls of the plant. This gradient was assumed to vary as a straight line between the two walls. Two minor loads were the live load and the thrust imposed by the 25 deg. Fah. temperature difference between the exterior members and the interior cross walls which are not in contact with the saturated backfill.

The design of the substructure of the pumping plant was divided into three parts. The first part consisted of the design of the base slab, including the vertical cantilever action of the exterior longitudinal walls and of the semi-circular ends. The base slab was designed as a continuous beam spanning between the cross walls and the semi-circular ends. Due to the cantilever action, moments and thrusts caused by the horizontal loads were applied at the semi-circular ends and the principal stresses in the base slab were computed on this basis. In the second part of the design the horizontal reinforcement in the longitudinal wall, cross walls and the semi-circular ends was determined by analysing horizontal frames cut at various heights in the structure. These frames were analysed by moment distribution, the moments being distributed into the cross walls, semi-circular ends, and the longitudinal walls. The lowest horizontal frame was considered at an elevation above the base slab where the vertical cantilever action in the walls was assumed to be non-existent. Each frame was designed to carry the full equivalent fluid pressure at that level, including the effect of the 10ft variation in the hydraulic gradient and the 25 deg. Fah. temperature differential between the interior and the exterior members. Below the motor floor,

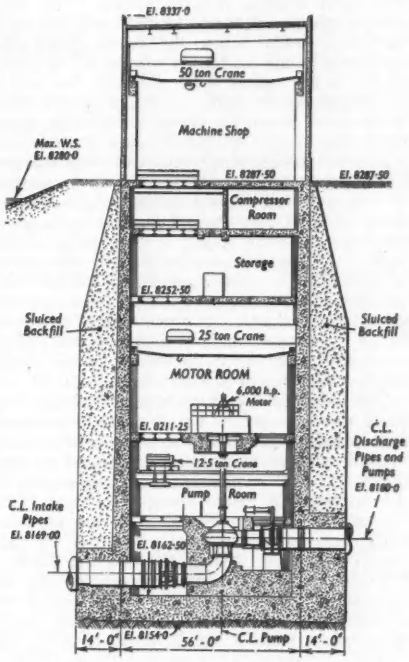


Fig. 11—Transverse sectional elevation of Granby pumping plant

where the horizontal loads are the greatest, the rib shortening in the end cross walls also was included because of its influence upon the moments and thrusts in the semi-circular ends.

The third part of the design, the transverse frame, proved to be the most complex. In the preliminary design a trial load analysis of the completed structure was made for the ultimate loading. It proved to be a valuable check for the detailed design of the transverse frame. The final analysis was performed by moment distribution and column analogy procedures. Both analyses showed that the inflection points in the buttresses at the opening for the motor room were actually inside the supports and not in the clear span. Agreement between the two methods was considered to be exceptionally good, in view of the unusual proportions of the frame.

One serious problem was encountered in the cross walls that was not anticipated when the

Fig. 10—Upper portion of Granby pumping plant and discharge conduits under construction

trial load analysis was requested. The final analysis showed that due to dead and live loads the cross walls below the motor floor had unexpected diagonal tensile stresses of the order of 250 lb per square inch, although the wall is 57ft high and 3ft thick. Although several relatively small openings pierce these walls, these openings did not materially contribute to the high stress. Photo-elastic and stress-coat analyses of this portion of the plate verified the magnitude of the diagonal tensile stresses as previously calculated. To help resist these stresses, diagonal reinforcement was added in both faces of the walls. As the compressive stresses introduced in the walls by the saturated backfill would tend to relieve these diagonal tensile forces, it was considered desirable that some backfill be placed before the entire structure was completed. Consequently, backfilling operations were begun before concrete was placed to elevation.

The sequence of construction of the transverse plate was believed to be of prime importance from a design standpoint, as is the case in many monolithic structures that are subjected to large horizontal and vertical loads. The framing of the intermediate floors above the motor room limited the height of many of the concrete placements to approximately 10ft. A separate design was made taking into account the first placement above the motor room as the top member of the frame and the weight of the wet concrete in the placement above it acting as a dead load. Backfill was assumed to be at the

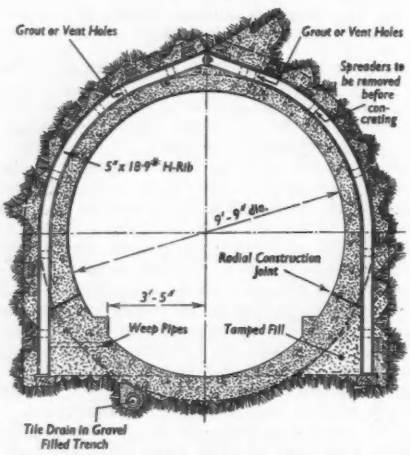


Fig. 12—Sectional elevation of Alva B. Adams tunnel

level of the first placement. When the third placement above was added as dead load, the first two lifts were assumed to form the top member of a new frame and the backfill was raised to the level of the previous placement. This process was repeated until the structure and backfill were brought to grade. This method of analysis and sequence of construction resulted in the critical loading condition for the portion of the plate above the motor floor.

The transition from the semi-circular ends to a rectangular shape at elevation 8272·50 presented an interesting problem because the remainder of the building, 65ft in height, is cantilevered out over the semi-circular ends. To carry these superstructure walls, the basement walls from elevation 8272·50 to 8287·50 were designed as horizontal girders to carry the floor and wall loads above them.

Alva B. Adams Tunnel

The drawing (Fig. 12) shows a sectional elevation of the Alva B. Adams tunnel, which receives water from the Grand Lake on the western slope and carries it under the Continental Divide to a point on the eastern slope on the Wind River 5 miles south-west of the village of Estes Park, Colorado. The concrete-lined tunnel has an inside diameter of 9ft 9in, a rated capacity of 550 cusecs and a length, from portal to portal, of 13·07 miles. Its west portal has an invert elevation of 8356·8 and its east portal one of 8249·3, resulting in a slope of about 8ft 3in per mile. At its eastern end, the tunnel discharges into the East Portal stilling basin, and the waters then flow through the 10ft 9in diameter Aspen Creek siphon and the Rams Horn tunnel to the penstock gatehouse of the power station on Marys Lake.

Marys Lake Power Station

The Marys Lake power station is a single-unit, base-load plant, which is situated on the western shore of the Marys Lake reservoir about 2½ miles south-west of Estes Park. This plant is the first one on the eastern slope to utilise the diverted irrigation water for the production of electrical energy. The entire annual diverted water flow of 310,000 acre-feet is available for power production, and the average annual output from the plant is about 47,600,000kWh.

The penstock gatehouse contains the equipment for the control of flow through the Marys Lake power plant. When the power plant is closed down, the flow is diverted at the gatehouse by means of a siphon spillway into a penstock by-pass chute around the power plant into the Marys Lake reservoir. A hydraulically operated, 8ft by 10ft 6in fixed-wheel gate is used to shut off the flow into the penstock. In case of a power failure, the gate can be hand-operated. The gatehouse also contains a well to facilitate float control of the governor gate limit and a second well to obtain float control of the pressure regulator valve when used as a synchronous by-pass. The Marys Lake penstock is a welded plate steel conduit 533ft long, 96in in diameter at the gatehouse and reduced to 72in in diameter at the power plant.

The Marys Lake power station plant is a conventional indoor power plant of reinforced concrete. It is designed to be unattended with remote operation, except for starting, being controlled from the Estes power plant by means of supervisory equipment operating over a metallic control conduit. The return water from the heat exchangers of the generator is used to heat the power station building partially. The generating unit is composed of a generator rated at 9000kVA and 0·90 power factor when driven at 327 r.p.m. by a turbine with a rated capacity of 11,300 h.p. at a 205ft head. The head varies from 205ft to 215ft, depending upon the tailwater elevation in the after bay. The best efficiency of the turbine is obtained at a net head of 212ft. The unit is designed for a runaway speed of 545 r.p.m. at a 215ft head. The switchyard of the station is a conventional outdoor installation with steel structures where power from the generating unit is stepped up through a bank of three oil-immersed transformers to 115kV and transmitted over a distance of about 2½ miles to the Estes power plant switchyard for distribution through the inter-connection grid system.

(To be continued)

Proposed Monorail System for Los Angeles

In 1953 the Los Angeles Metropolitan Transit Authority retained Coverdale and Colpitts, consulting engineers, of New York, to make a study of the proposed monorail system which is to extend over a distance of 45·7 miles from the San Fernando Valley to Long Beach, and details of the scheme have now been announced.

The system planned has been designed as an inter-urban rather than an urban distribution system, and to obtain a desirable overall speed the stations have been placed an average of 2·8 miles apart. It is contemplated that the existing bus and trolley bus lines will serve as collecting and distributing feeders. With high rates of acceleration and deceleration, it is felt that a maximum speed between stations of 60 m.p.h. can be reached, resulting in an average speed of 40 m.p.h. The entire length of the line is 45·7 miles and the estimated running time for a through trip is sixty-seven minutes. At each station, except the two in the central business district, which are underground, and the one at the southern terminus, large car parks will be maintained, providing total parking space for 4500 cars at a nominal fee for the day. The availability of such parking space has proved useful in other American cities as a means of widening the area served by inter-urban rapid transit systems.

In the monorail system proposed the carriages are suspended from a single rail carried on a girder supported at intervals of about 60ft by transverse bents generally in the form of a "T" with the columns centrally situated in the street so as to interfere as little as possible with street traffic. The stations on the overhead parts of the line are generally over the streets with intermediate platforms below the train platforms. Access is by stairways or escalators. It is contemplated that the trains will be composed of six carriages, which will be of all-metal construction, each seating sixty-seven passengers. Each carriage is suspended from two bogies and each of the two bogies is provided with two double-flange wheels. The centre of gravity of the carriage is directly below the rail. Side clearances permit sway of the carriage body in passing around curves or by wind pressure. The supporting structure is designed so as to provide 16ft clearance between the bottom of the carriages and the surface of the street. This results in a girder elevation of about 26ft above the road surface. Each bogie frame will carry two 100 h.p., three-phase, a.c. squirrel-cage, induction motors propelling the carriages through hydraulic torque converters. Three-phase, 60 c/s, a.c. at 2300V is delivered to the carriages by a dual-wire contact system, and the running rail has the three-phase conductors. Energy is supplied from simple stationary transformer substations situated in the car parks adjacent to passenger stations. Each substation is fed over two independent supply lines by the utility serving the area where the substation is situated.

Trains are turned by running around a loop track. Such turnback loops would be provided at each end of the line and at two intermediate points, so that service could be adjusted to meet demand. The signal system is planned for a maximum of forty trains per hour in one direction on a single track or a train interval of one and a half minutes. This signal system includes cab signal indication so that the motorman is given notice of signal aspects ahead, thus avoiding any possible confusion with background coloured lights. It is equipped to stop trains automatically should a motorman inadvertently fail to obey a stop signal.

According to the consulting engineers, there is no aspect of this installation that has not already been proved in practice. The assembly, however, has not yet been proved, and it has been recommended that trials be conducted on models of reasonable size in order to test particularly the operation of the motors and the signal system, as well as the sway of carriages on curves and the ability to hold them at station platforms magnetically.

Reduction in Price of Titanium

An important development in the industrial application of titanium occurred recently when the Titanium Metals Corporation of America announced a 55 cents per lb cut in the price of titanium sponge—the biggest cut since the metal went into commercial production in the United States in 1948. A few days later, du Pont, the other large American sponge producer, announced that it would follow suit. This brings the price down to 3·95 dollars per lb. In accordance with the Kroll process manufacturing method, titanium sponge is an intermediate stage of the primary metal: the ore is processed into sponge, then the sponge is melted down into ingots to be fabricated into mill shapes. The Titanium Metals Corporation sells very little sponge on the open market; it uses most of its own production and sells mainly fabricated and semi-fabricated products. The company also cut the prices of these mill products by 1 dollar to 3 dollars per lb. Because of its combination of strength, light weight, and corrosion resistance, titanium is felt to have an excellent potential market. Two things have held back its development so far: high cost and a limited supply. The search for lower-cost processes for producing titanium sponge has been going on for years, and the American Government is now sponsoring several pilot plant developments. Meanwhile, the situation is helped by price cuts like the current one, which the firm attributes to "growing efficiency and sustained capacity operation."

Industrial and Labour Notes

The Railway Strike

On Tuesday evening, it was announced that the strike of members of the Associated Society of Locomotive Engineers and Firemen, employed on British Railways, had ended. The strike, which began at midnight on May 28th, arose over the question of wage differentials. The decision to terminate the strike followed many hours of discussions—which began last Friday—between the executive of A.S.L.E.F., the Minister of Labour and his officials, and representatives of the British Transport Commission. Officials of the National Union of Railwaymen, which includes a small proportion of locomotive men in its membership, were kept informed of the progress of the talks.

Statements made on Tuesday evening by the Ministry of Labour and the British Transport Commission gave some details of the "basis for a settlement." It was agreed that, within seven days of the cancellation of the strike and the resumption of work, the British Transport Commission would negotiate with both unions (A.S.L.E.F. and the N.U.R.) representing footplate staff. The Commission said that it accepted the principle that there should be higher rewards for special skill and responsibility, where not already given, and it further agreed that there was a case for such higher reward for certain sections of the footplate staff. The A.S.L.E.F. agreed that an extension of mileage payments should be accepted as part of the higher rewards. Then, it was agreed to ask the Minister of Labour to appoint "a referee of impartiality, integrity and acknowledged judgment" to name the figures which he considered appropriate as basic wages for drivers and motormen, after hearing the views of the parties privately and separately. In this context, the N.U.R. is to be entitled to be heard by the referee, and the undertaking has been given that when the referee gives his decisions "they shall be accepted immediately and without question by all parties." Finally, it was agreed that when a settlement has been reached, the application of the principle of higher rewards for special skill and responsibility to other than footplate staff "shall not be held to justify a further upward revision of the settlement for footplate staff."

Shortly after the announcement had been made that these proposals were acceptable, the Minister of Labour stated that Lord Justice Morris had been appointed to act as the referee.

Iron and Steel Production

Figures issued by the Iron and Steel Board show that, during May, the production of steel ingots and castings in Great Britain averaged 401,600 tons a week. This represents an annual output rate of 20,884,000 tons, the highest achieved in any month. In May last year, the annual output rate for steel was 19,476,000 tons. Pig iron production in May averaged 241,800 tons a week, and was thus at an annual rate of 12,574,000 tons, compared with a rate of 12,033,000 tons in May, 1954.

The figures for May were not affected by the railway strike which began on May 28th. The Iron and Steel Board has pointed out, however, that the results for June will inevitably show a reduction from these high rates of output because of the strike. The precise effect, the Board says, cannot yet be assessed as conditions have varied in the different steel making districts.

Iron and Steel Control

In the House of Commons on Tuesday, the Prime Minister, Sir Anthony Eden, announced that the Government had decided to transfer to the Board of Trade the responsibility hitherto exercised by the Ministry of Supply in relation to the iron and steel and non-ferrous metals industries and the engineering industries. Sir Anthony said that that decision had been made after consultation with both sides of the industries concerned. The purpose of the change, he explained, was to relieve the Ministry of Supply of duties extraneous to its prime task of supplying the armed Forces, and to associate the Board of Trade more closely with certain major industries which were of great importance to the export trade. The change, the Prime Minister stated, would take place in about a month's time.

Employment and Unemployment

In its latest report on the employment situation in Great Britain, the Ministry of Labour states that, at the end of April, the total working population numbered 23,836,000 (16,060,000 men and 7,776,000 women) which indicated an increase of 36,000 during the month. Of the total, 22,807,000 were in civil employment at the end of April, which was 75,000 more than at the end of March, and 335,000 more than a year ago.

An analysis of the civil employment figures shows that, during April, there was an addition of 15,000 to the number at work in the basic industries, bringing the total engaged in those industries to 3,984,000, compared with 4,009,000 a year earlier. Nearly all the increase in April occurred in transport and agriculture and is therefore described by the Ministry as seasonal. In the manufacturing industries, the labour forces increased by 23,000 to 9,233,000, compared with 8,941,000 a year earlier. All the manufacturing groups, except textiles, reported increased employment. In the group described as "engineering, metal goods and precision instruments," the labour force totalled 2,758,000, denoting an addition of 13,000 during April. At the end of April last year, this group of industries was employing 2,611,000 people. In other industries and services, the principal changes in April were in building and contracting, an addition of 12,000 bringing the number employed to 1,440,000, and in "professional, financial and miscellaneous," in which group an increase of 10,000 brought the number engaged to 4,058,000.

Unemployment figures given in the Ministry's report relate to May 16th, when 223,643 were registered as out of work, compared with 260,129 on April 18th. It is estimated that the number of people registered as unemployed on May 16th represented 1 per cent of the total number of employees. Of the total unemployed, 25,000 were described as being temporarily stopped.

Movement of Cargoes at the London Docks

The London Chamber of Commerce has stated that it recently appointed a special sub-committee to inquire into the working of the London Docks, with a view to expediting the movement of import and export cargoes through the port. This sub-committee has already made considerable progress and expects to submit a report very shortly. It is not, of course, concerned with delays such as those caused by the strike of stevedores in the Port of London, which started nearly a month ago, and which, as these notes go to press, is still in progress. In its statement, the London Chamber of Commerce recalls that last December its council adopted a report on London's road traffic problems, which had been prepared by the transport committee. Dealing with London docks and wharves, this report emphasised that partly loaded vehicles were one of the causes of traffic congestion at the docks. It was proposed that a special road haulage organisation should be set up to convey in full lorry loads small parcels consigned to or arriving at the docks, thus reducing the number of vehicles required for that purpose.

Coal

During a speech at Bedlington, Northumberland, last Saturday, Mr. Arthur Horner, general secretary of the National Union of Mineworkers, said that there was much concern in this country about coal supplies and that there was a growing tendency to blame the miners and nationalisation. But, Mr. Horner asserted, we were now exporting as much coal as we did in 1938 and 1939, not as raw coal, but embodied in the products of manufacturing industries. The miners, he added, were keeping up their present output with a manpower 60,000 fewer than in 1939. Output at the face was rising, but coal consumption was increasing at the rate of 5,000,000 tons a year.

It was estimated, Mr. Horner continued, that between 10,000,000 and 12,000,000 tons of coal would have to be imported this year to maintain full employment. If that was realised, the cost to the national economy would be at the rate of £100 million a year, although there would be some recovery through the maintenance of production. Mr. Horner went on to say that the transaction could produce for the National Coal Board a deficit of £30,000,000 a year, but, he argued, that ought to be a national charge and not set against the finances of the Board. In any case, he said, the union would not listen to arguments arising from that loss in any negotiations to obtain further improvements in the wages and conditions of the miners.

Overseas Trade

According to provisional figures issued by the Board of Trade, the value of the United Kingdom's exports in May (in which there were twenty-five working days) was £249,400,000. The average export rate in April and May was almost the same as in the first quarter of this year, and 9 per cent more than in the comparable months of last year. Imports in May totalled £290,300,000 which brought the average value for April and May to 9 per cent below the level of the first quarter, though it was 8 per cent higher than in the corresponding period of last year.

These figures were mentioned by the President of the Board of Trade, Mr. Peter Thorneycroft, in Parliament last Friday during the debate on the address in reply to the Queen's Speech. He said that a country as dependent as ours upon foreign trade, amid world markets as inherently unstable as they always were, could hardly ever expect to find a situation which did not justify some anxiety. At the same time, however, the situation was not devoid of certain fairly satisfactory features. Mr. Thorneycroft went on to say that production was 5 or 6 per cent above that for the corresponding period of last year, and perhaps 3 or 4 per cent above the average for the whole of 1954. Exports last year, he added, were a record, although there were signs at the end of the year that the upward trend was levelling out. It now appeared, Mr. Thorneycroft continued, that that was not so because exports were still going up. In the first quarter of this year engineering exports were 10 per cent above the average for 1951, and, in general, we were now exporting at the rate of £10,000,000 a day.

Wage Agreements in the U.S.A.

During the past week, some details have been published about agreements on guaranteed annual wages which have been made between the United Automobile Workers, an American trade union, and the Ford Motor Company and General Motors Corporation respectively. In the case of the Ford Company, it has been stated that the agreement involves the establishment, by the company, of a fund of 55,000,000 dollars to provide benefits to "laid-off" employees. Such allowances, when added to state unemployment benefits, will guarantee workers from 60 to 65 per cent of their normal pay for a maximum period of twenty-six weeks. The terms of the agreement provide for certain other concessions, including a higher "annual improvement factor," which is an annual pay increase to compensate workers for the greater efficiency of machinery. The agreement marks the settlement of a dispute over which a strike at the Ford Company's plants in the U.S.A. had been threatened. The agreement between the union and the General Motors Corporation is very similar in detail to that made with the Ford Motor Company. It involves the establishment of a trust fund stated to be of the order of 150,000,000 dollars.

Personal and Business

Appointments

MR. J. E. SPENCE, M.I.Mech.E., has been appointed general sales manager of B.E.N. Patents, Ltd., High Wycombe, Bucks.

MR. A. BOYES has been appointed general manager of East Sussex Engineering Company, Ltd., Phœnix Iron Works, Lewes, Sussex.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough, announces the appointment of Mr. Percy Evans as home sales manager.

MR. E. CATTANES has been appointed a senior commercial executive of the Solartron Electronic Group, Ltd., Thames Ditton, Surrey.

COLLOIDAL GRAPHITE, Ltd., 6/7, St. Dunstan's Lane, London, E.C.3, states that Mr. R. W. Burchhardt, its technical manager, has been appointed a director.

BAILIE BRUCE RUSSELL, M.I.E.E., engineer and manager in Scotland for Johnson and Phillips, Ltd., has been appointed to the electricity consultative council for the South of Scotland district.

BRITISH NATIONAL ELECTRICS, Ltd., Charlton, London, S.E.7, announces the appointment of Mr H. J. Collins, as general manager. He has been technical manager of the company since 1947.

MR. G. K. N. SMITH, Mr. C. R. NICHOLLS and Mr. R. J. LAKELIN have been appointed directors of the Lilleshall Company, Ltd., and the Lilleshall Iron and Steel Company, Ltd., St. George's Shropshire.

WINSTON ELECTRONICS, Ltd., Shepperton, Middlesex, announces the appointment of Mr. R. L. Green, A.M.I.E.E., as senior development engineer, responsible for telecommunications research and development.

MR. F. E. MCGINNETY has been appointed director, inspectorate of electrical and mechanical equipment, in the Ministry of Supply. For the past year he has been assistant director (signals) of electronics research and development (defence).

THE NATIONAL COAL BOARD has announced the appointment of four staff directors of divisional boards. They are : Mr. L. E. Bourke, Scottish division ; Mr. J. V. Wood, Northern (N. and C.) division ; Mr. J. Macdonald, North Western division; Mr. G. Essame, West Midlands division.

MR. S. S. DAWES, M.I.Mech.E., president of the Institute of the Motor Industry, has been elected a vice-president of the Federation Internationale des Societies d'Ingenieurs et de Techniciens de l'Automobile. Mr. Dawes has also been elected an honorary member of the Associazione Tecnica Automobile of Italy.

THE CENTRAL ELECTRICITY AUTHORITY states that Mr. R. S. Atkinson, A.M.I.Mech.E., A.M.I.E.E., has been appointed chief generation engineer (operation) in the South Wales division. He succeeds Mr. E. Hywel Jones, M.I.Mech.E., M.I.E.E., who has been appointed deputy chief engineer (generation) of the South of Scotland Electricity Board.

BABCOCK AND WILCOX, Ltd., states that Mr. H. McAndrew, A.M.I.Mech.E., has been appointed chief engineer of Edwin Danks and Co. (Oldbury), Ltd. He has been deputy chief engineer since 1952. Mr. McAndrew succeeds Mr. W. F. Johnston, M.I.Mech.E., who is retiring. He joined Edwin Danks and Co. (Oldbury), Ltd., in 1927, and has been chief engineer since 1945.

Business Announcements

RHODEN PARTNERS, Ltd., has moved to 51, North Row, London, W.1 (telephone, Mayfair 6248).

MR. MICHAEL CLARK, director of the electronics and equipment group of the Plessey Company, Ltd., is visiting the U.S.A.

BYRON BUSINESS MACHINES (JOHN JARDINE, Ltd.) is opening new showrooms at Ingersoll House, Kingsway, London, W.C.2, on June 24th.

WEST PRODUCTS (METALS), Ltd., states that it has established an investment castings plant at 161, High Street, Hampton Hill, Middlesex (telephone, Molesey 1784).

WEST'S PILING AND CONSTRUCTION COMPANY, Ltd., states that its address is now Bath Road, Harmondsworth, West Drayton, Middlesex (telephone, West Drayton 2288).

WINSTON ELECTRONICS, Ltd., has moved to a new factory at Govett Avenue, Shepperton, Middlesex (telephone, Walton-on-Thames 2732 ; telegrams, Control, Shepperton).

THE GAS COUNCIL states that its Birmingham research station is to be known in future as the Midlands Research Station. It is now accommodated in new laboratories at Wharf Lane, Solihull, Warwickshire.

THE UNIVERSITY OF LONDON has conferred the degree of D.Sc. (Engineering) on Dr. A. Rosen, M.I.E.E., for his work on telecommunication cables. Dr. Rosen is consultant engineer of British Insulated Callender's Cables, Ltd.

PARSONS MARINE TURBINE COMPANY, Ltd., is now the official title of the company formerly known as Parsons Marine Steam Turbine Company, Ltd. Its address (Turbinia Works, Wallsend-on-Tyne), constitution and control are unchanged.

EDGAR ALLEN AND CO., Ltd., Sheffield, has acquired the business of J. H. Humphreys and Sons. A new company has been formed under the title of J. H. Humphreys and Sons, Ltd., and the business will be carried on from Blackriding Electrical Works, Werneth, Oldham.

CLIMAX MOLYBDENUM COMPANY OF EUROPE, Ltd., states that its registered office is to be transferred on July 1st to 99, Pinstone Street, Sheffield, 1. Mr. A. H. Bunker and Mr. R. E. Warriner have been appointed directors on the resignation of Mr. Carl M. Loeb and Mr. R. L. Prain. Mrs. J. Critchley has been appointed secretary of the company.

THE MAGNETIC EQUIPMENT COMPANY, Ltd., Lake Works, Portchester, Hants, states that it has established the following agencies :—Holland, Berg and Burg, De Ruyterkade 141-142, Amsterdam; Belgium, Willy Depireux, Rue Hector Denis 74, Mont-sur-Marchienne, Charleroi ; Eire, The Modern Plant and Appliance Company, 64, Aungier Street, Dublin.

PERMALI, Ltd., Gloucester, states that its American subsidiary, Permali Inc., is building a new factory at Mount Pleasant, Pennsylvania. Permali, Ltd., announces also that, following negotiations with Jablo Plastic Industries, Ltd., two new subsidiary companies have been registered in this country. They are : Hydulignum-Jabroc (Tools), Ltd., Haddenham, Bucks, for manufacturing metal-forming tools and jigs, and Jabroc, Ltd., Mill Lane, Waddon, Surrey, for the manufacture of densified wood laminates.

THE DAVID BROWN CORPORATION, Ltd., states that Mr. J. Whitehead, a director and general manager of the tractor group, has relinquished his seat on the boards of Aston Martin, Ltd., and Lagonda, Ltd., in order to concentrate on developments arising from the recent acquisition by the David Brown group of Harrison, McGregor and Guest, Ltd. Mr. L. V. Gallagher, manager of the automobile division of David Brown Tractors (Engineering), Ltd., has rejoined the agricultural side as manager of Harrison, McGregor and Guest, Ltd.

Contracts

F. PERKINS, Ltd., Peterborough, has received an order from P. Petropoulos and Co., its distributors in Greece, for 548 diesel engines for direct export.

H. WIDDOP AND CO., Ltd., has received orders for three Mark G.M.B.5 diesel engines of 550 b.h.p. for trawlers to be built by Richards Iron Works, Ltd., and two new " B " engines of 660 b.h.p. for trawlers to be built by John Lewis and Sons, Ltd.

HEAD WRIGHTSON PROCESSES, Ltd., announces that, in conjunction with the Fluor Corporation, Ltd., it has received an order for two gas dehydration plants, to dehydrate 18,000,000 cubic feet of gas each daily, from the Gas and Fuel Corporation of Australia. These plants, which will be erected at Morwell, will process gas extracted from the brown coal deposits nearby and supplies will be piped to the city of Melbourne.

THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD has placed the first of the main contracts for the Orrin hydro-electric scheme (constructional scheme No. 29). Duncan Logan (Contractors), Ltd., has been awarded the contract to build Orrin dam a structure 150ft high ; Whatlings, Ltd., has been given the contract for the 16,000ft long tunnel of the scheme. The value of the contracts is approximately £4,300,000.

Miscellanea

CENTENARY OF LONDON'S MAIN DRAINAGE.—An exhibition commemorating the centenary of London's main drainage service is to be held at the County Hall, S.E.1, from July 16th to July 22nd. The development of the service since 1855 will be illustrated by documents and models, and the exhibition will include film shows and lectures.

GERMAN INDUSTRIES FAIR, HANOVER.—In describing the exhibit of Klockner-Humboldt-Deutz A.G. at the German Industries Fair in our issue of June 3rd, we inadvertently gave the address of A. Kracko, Ltd., the firm's representative in Great Britain, as 24, Drewstead Road. The correct address is 84, Drewstead Road, London, S.W.16.

AIRPORT CUSTOMS FACILITIES.—The Association of British Chambers of Commerce has sent a note to the Treasury and the Minister of Transport and Civil Aviation, calling upon the Government to reverse present policy and to provide customs facilities at the smaller civil airports by making customs officers available on an " on call " basis from neighbouring ports.

JET DEFLECTOR FOR AIRCRAFT BRAKING.—The Bristol Aeroplane Company, Limited, and the French national aircraft engine firm, SNECMA, have entered into a licence agreement under which the Bristol Company secures rights for SNECMA's jet deflector and reverser device for application to the Bristol range of gas turbines. This device is a practical solution to the problem of reducing the landing run of jet aircraft.

LLOYD'S REGISTER OF SHIPPING.—At a meeting of the General Committee of Lloyd's Register of Shipping held on June 9th, Sir Ronald Garrett was re-elected chairman for the ensuing year ; Sir Guy Ropner, deputy-chairman and chairman of the sub-committees of classification ; Mr. J. E. Green, deputy-chairman and treasurer, and Mr. R. M. Turnbull, vice-chairman of the sub-committees of classification.

PRINTING EXHIBITION.—The International Printing Machinery and Allied Trades Exhibition will be held at Olympia, London, from July 5th to 16th, and is the tenth to be held in this country. These exhibitions began in 1904 and the last took place in 1936. The number of exhibitors is 330, including forty from eight overseas countries, and leading manufacturers will be showing the latest developments in printing machinery.

INSTITUTION OF STRUCTURAL ENGINEERS.—We are informed that at the annual general meeting of the Institution, held on May 25th, the following officers were elected : President, Mr. Stanley Vaughan ; Vice-Presidents, Professors A. G. Pugsley and A. J. Ockleston and Messrs. J. Guthrie Brown, G. S. McDonald, L. E. Kent and W. H. Woodcock ; Members of Council, Sir Donald Bailey and Messrs. T. F. Burns, F. M. Bowen and R. W. Schofield ; Associate Members of Council, Messrs. R. C. Buxton and A. S. Sinclair.

MR. JOHN AUSTIN.—It is with regret that we record the death of Mr. John Austin which occured on Friday of last week. Mr. Austin, who was 70 years of age, retired in 1949 from the position of chief superintendent engineer of the Cunard Steam Ship Co., Ltd., after 37 years' continuous service. He became chief superintendent engineer of the Cunard Company in 1919, and of Cunard White Star, Ltd., in 1934, and during his tenure of office was responsible for the machinery installations of many of the company's ships, including the "Queen Mary" and "Queen Elizabeth."

ROAD ENGINEERS' CONTINENTAL VISIT.—The Pavings Development Group of the Cement and Concrete Association 52, Grosvenor Gardens, London, S.W.1, has organised a visit to road construction sites in Denmark, Germany and Holland, to take place at the end of August. The sites to be visited include the Copenhagen ring road and a motorway under construction from Copenhagen to the North, an experimental road near Hanover, the Güttingen-Northeim autobahn and other German motor roads, two Dutch motorways at present under construction, and the Velsen tunnel.

ELECTRONICS EXHIBITION.—The Institution of Electronics (Incorporated) is to hold its tenth annual Electronics Exhibition at the College of Technology, Manchester, from July 14th to 20th. There will be a Scientific and Industrial Research Section and a Manufacturers' Section and also a series of lectures, numbering about forty, and film shows. The latter will commence at 11.15 a.m., 2.45 p.m. and 7.30 p.m. each day. Lecture and film show programmes (post free 4½d.) and lecture admission tickets may be obtained from the Exhibition Honorary Organising Secretary, Mr. W. Birtwistle, 78, Shaw Road, Thornham, Rochdale, Lancashire.

ANGLO-AMERICAN AERONAUTICAL CONFERENCE.—The fifth Anglo-American Aeronautical Conference will be held in Los Angeles from June 20th to July 1st. Altogether eleven papers will be contributed by the Americans and nine by the British delegation. The titles of the British papers are as follows : " Operation of Turbo-Prop Aircraft," by P. G. Masefield ; " Stress Analysis of Multi-Web Boxes," by W. S. Hemp ; " The Interaction Between Shock Waves and Boundary Layers," by D. W. Holder ; " The Behaviour of Boundary Layers in Supersonic Flow," by R. J. Monaghan ; " Fatigue of Aircraft Pressure Cabins," by P. B. Walker ; " Some Influences of Equipment Installations and Systems on Aircraft Design," by C. F. Joy ; " Jet Noise," by F. B. Greatrex ; " Low Consumption Turbine Engines," by A. A. Lombard, and " Power Plants for Supersonic Flight," by E. S. Moult. It is not yet known how many American delegates will be attending the conference, but it is expected that from the United Kingdom there will be about 128 delegates. Most of the British visitors will, in addition to attending the lectures, have a programme of visits to aircraft factories and research establishments. There will be a number of social functions which should also appeal to the wives accompanying the delegates. The American papers to be read at the conference will be as follows : " Airline Use of Elementary Statistical Methods in Aircraft Performance Measurement," by W. C. Mentzer ; " Design of High Speed Aircraft," by E. H. Heinemann ; " Design of Large Helicopters," by Bartram Kelley ; " Shock Tubes," by G. N. Patterson ; " Hypersonic Flow," by Lester Lees ; " Some Results of the Princeton University Smoke Flow Tunnels," by David C. Hazen ; " Power Control Systems for Aircraft," by John W. Ludwig ; " Combustion for Aircraft Engines," by Walter T. Olson, and " The Variable Stator Jet Engine," by C. J. Walker.

British Patent Specifications

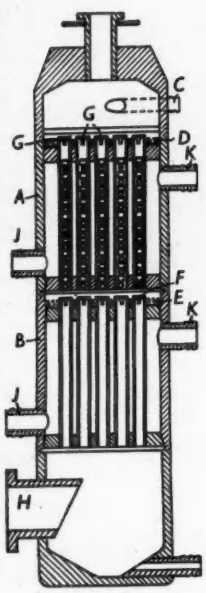
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 6d. each.

HEAT EXCHANGERS

730,375. May 31, 1951.—HEAT EXCHANGE APPARATUS, The Farbwerke Hoechst Aktiengesellschaft vormals Meister Lucius and Brüning, Frankfurt (M)—Hochst, Germany.

The invention provides heat exchange apparatus comprising a jacket for the passage of a liquid or gaseous heating or cooling medium through it and a column consisting of a bundle of fluidtight graphite tubes surrounded by the jacket, the tubes being suitable for the passage of a liquid to be heated or cooled or of a liquid and gas undergoing heat exchange. The apparatus is especially suitable for the absorption of hydrochloric acid coupled with a heat exchange process. As shown in the drawing, the hydro-chloric acid absorption apparatus consists of several short superposed sections, each consisting of a bundle of tubes and constructed as a heat exchanger. Only two sections *A* and *B* are shown. The upper ends of the tubes of each section are so constructed that the water introduced at the top of the column through an inlet *C* and serving for the absorption of hydrochloric acid wets the inner walls of the tubes uniformly in the form of a thin film. In this way the liquid leaving an upper section does not flow directly into the tubes of the next lower section, but collects on the horizontal floor *D* or *E*, from which it is uniformly distributed over all the tubes. This uniform distribution and also the film-like formation of the whole of the flowing liquid on the inner walls of the tubes is attained by providing closures *F* on the tops of the upper ends of the tubes, in order to prevent drops of liquid from falling into them, and by forming in the upper ends of the tube lateral distributing slots *G*, a number of which are provided round the circumference of each tube. The hydrochloric acid gas is introduced through an inlet *H* and the cooling water enters the cooling jacket of each section through an inlet *J* and leaves an outlet *K*. In this manner an optimum energy exchange between the treated liquid and the cooling water is attained.—*May* 25, 1955.

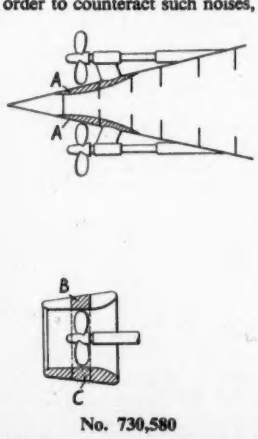


No. 730,375

MARINE ENGINEERING

730,580. May 2, 1952.—REDUCING NOISES AND VIBRATIONS PRODUCED BY PROPELLERS, Ludwig Kort, Richard Wagnerstrasse 21, Hanover 1 N., Germany.

The invention relates to means for reducing vibrations and noises produced by the propellers of ships. In order to counteract such noises, according to the invention, the plating forming the ship's hull is covered inside with anti-vibration or noise-absorbing material near the circumference of the propeller disc. The anti-vibration or noise-absorbing material may consist of concrete, lightweight concrete, rubber, wood, artificial resin or similar products, i.e material by which the vibrations and the noises are reduced. The upper view is a plan view of the stern end of a twin-screw ship, in which in the region of the propeller the plating is covered with a thick layer *A* of anti-vibration or noise-absorbing material; the lower left-hand view is a section through a Kort nozzle, the double-walled ring of which is either, as indicated by *B* in the upper part of the section, partially filled with anti-vibration or noise-absorbing material or, alternatively, as indicated by *C* in the lower part of the section, is entirely filled with such material. In a double-walled Kort nozzle the plating is covered on the inside of the ring with a thick layer of anti-vibration or noise-absorbing material.—*May* 25, 1955.

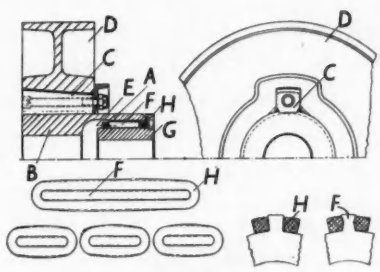


No. 730,580

POWER TRANSMISSION

730,521. July 2, 1953.—ELASTIC TOOTHED COUPLING, Gunther Grassmann, Eddesse No. 40 über Peine (Hanover), Germany.

An object of the invention is to provide a coupling which is cheap to produce, is simple in operation, consists of few parts, and has only very small moments of inertia. As shown in the drawing, a bell-shaped internally toothed coupling box or sleeve *A* is made integral with a coupling member *B*, the teeth being axially disposed. The part *B* carries in the axial direction wedge keys *C*, and on to these keys is a brake drum *D*. In its interior the coupling sleeve *A* has axially parallel grooves *E* open towards the end face of the sleeve, and receiving elongated teeth *F* which are introduced into the grooves in the axial direction and which are arranged on the coupling member *G*. Each tooth is surrounded by a continuous cover *H* of resilient material, which can easily be pulled off. A tooth of this type with its cover *H* is shown in the lower left-hand views. As can be seen, the tooth may be divided longitudinally and fitted with an elastic cover *H* on each section. The lower right-hand view shows the teeth *F* in two different cross-sectional shapes, undercut or recessed on their faces. This construction enables the covers *H* to hold more securely.—*May* 25, 1955.

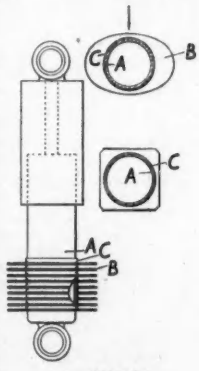


No. 730,521

ROAD TRANSPORT

730,684. March 4, 1953.—HYDRAULIC SHOCK ABSORBERS, Morris Motors, Ltd., Cowley, Oxford. (*Inventors: William John Daniels and Albert Edward Dixon.*)

The invention relates to telescopic hydraulic shock absorbers. As shown in the drawing, the recuperation chamber *A* of the shock absorber is provided with external secondary heat transfer surfaces formed by metal fins *B* secured to the lower part of the chamber. These fins have a flanged central aperture. Not only do the flanges *C* serve to space the fins apart when assembled on the chamber, but they also afford an increased area of contact for the conduction of heat to the fins. By making the fins of oval shape they can be arranged to the best advantage as regards exposure to the cooling air stream when the vehicle is in motion. The cooling fins may be of any desired cross-sectional shape and usually the hottest part of the casing *A* is found to be the zone which extends over approximately 2in from its lower end, and this zone is accordingly the most effective place from which to dissipate the heat by the fins.—*May* 25, 1955.

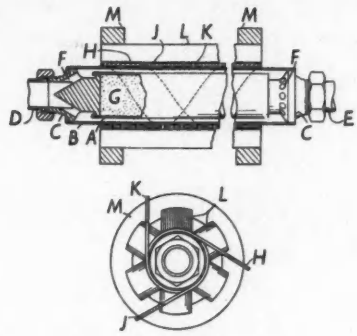


No. 730,684

ELECTRICAL ENGINEERING

730,943. September 25, 1953.—ELECTRO-MAGNETIC PUMPS, The English Electric Company Limited, Queens House, 28 Kingsway, London, W.C.2. (*Inventor: Alan Stephen Fenemore.*)

The invention relates to electromagnetic pumps for pumping electrically conducting liquids. Referring to the drawing, the pump comprises inner and outer concentrically spaced thin-walled metal tubes *A* and *B*, which are welded at the ends to non-magnetic end pieces *C*. These end pieces are shaped to receive inlet and outlet pipes *D* and *E*, held in position by nuts. Inclined ports F, in the end pieces allow free flow of fluid through the annular duct formed between the two tubes. The inner tube is filled with iron powder *G*. The travelling magnetic field is established by a single layer three-phase a.c. strip winding wound helically round the outer tube *B*, the three interleaved phases being indicated at *H*, *J* and *K* respectively. The magnetic circuit is completed by a number of angularly spaced packs of axially extending laminations *L*, fitted round the winding and held in position by non-magnetic clamping rings *M*. These rings may be formed from insulating material and, if desired, may be used as an anchor for the ends of the winding. The winding shown has a phase spread of 120 electrical degrees and has less output than a winding otherwise similar but with a phase spread of 60 electrical degrees. A winding of the latter type may also be used by winding six interleaved helixes, and such a winding may still be fed from a three-phase A.C. source by providing inter-connections between the appropriate helixes. In operation, the winding establishes a travelling magnetic field which passes transversely through the annular pumping duct and which has a component travelling axially along the duct. This sets up eddy currents in the electrically conducting liquid which react with the magnetic field to produce a force tending to propel the liquid through the annular pumping duct.—*June* 1, 1955

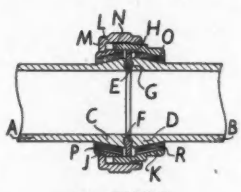


No. 730,943

TUBE AND PIPE COUPLINGS

730,813. January 1, 1953.—PIPE COUPLINGS, The De Laval Separator Company, Poughkeepsie, New York, U.S.A.

The invention relates to couplings for connecting pipe sections and it provides a coupling which can be readily disassembled for cleaning purposes, forms a tight joint between the pipes, and accommodates out-of-roundness of the pipes without imposing undue stresses on them. The coupling may be used to particular advantage for coupling glass pipes. Referring to the drawing, the pipes to be coupled are shown at *A* and *B*. They are made of glass and have enlarged tapered end portions *C* and *D*. In the opposing ends of the pipes are annular recesses *E* and *F*, which are part circular in cross-section. An annular gasket *G* of rubber or other elastic material is fitted in the recesses. For ease in handling the gasket during assembly of the coupling, the gasket is provided with a flange *H* which protrudes radially beyond the enlargements *C* and *D*. These enlargements of the pipes are surrounded by metal rings *J* and *K*, the internal surfaces of which have tapers complementary to those on the pipe enlargements. The ring *J* has a portion which fits closely in the other ring *K* and is slidable therein, and the two rings are surrounded by a nut *L* having a threaded connection with the ring *K*. A flange *M* on the nut



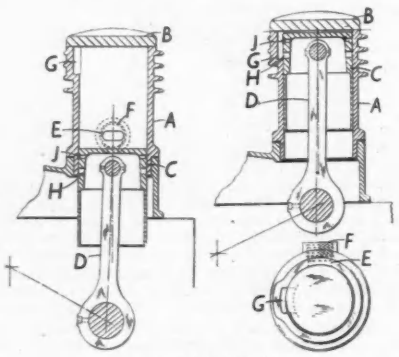
No. 730,813

is engaged in a circumferential notch in the ring *J* and, by screwing the nut *L* in one direction on the ring *K*, the two rings are drawn together. Within the metal rings are bands *N* and *O*, of a yielding material and these bands are formed with longitudinal grooves *P* and *R*, in their outer surfaces. The groove of each band weakens it locally between its opposing ends and thereby forms a hinge on which the band can be opened and closed. The opposed ends of each band are preferably formed with interlocking portions to maintain the continuity of the band and hold the ends in alignment.—*June* 1, 1955.

PUMPS

731,037. August 10, 1953.—A RECIPROCATING SUCTION PUMP, Humber Limited, and Eric William Coy, both of the company's address, Stoke, Coventry, Warwickshire.

The pump is intended for use as a source of suction for operating the brakes and other services of a motor vehicle having an engine constructed and located as described in Specification No. 648,117. It is driven by a connecting rod coupled to an end of one of the engine rocker arms. From the drawings it will be seen that the pump comprises a cylinder *A* closed at one end by a head *B* and a piston *C* with a connecting rod *D*. The piston has a skirt of substantial length open to the engine casing which has a vent



No. 731,037

to atmosphere. The cylinder has an inlet port *E* near the outer end of the suction stroke and leading to a socket *F* for a connection to a suction tank or reservoir. It also has a by-pass port *G* at its closed end. The piston has a main discharge port *H* near its crown and a small auxiliary discharge port *J* nearer to the crown, these parts registering with the by-pass when the piston is at the end of its compression stroke as shown. The ports *H* and *J* are duplicated on the opposite side of the piston. The operation of the pump, starting from the position shown in the right hand view is described as follows. As the piston moves down and the ports *H* and *J* pass the edge of the by-pass port *G*, the cylinder is closed and further movement of the piston causes a reduction of pressure in it which intensifies until the port *E* is uncovered by the piston when air passes from the suction tank into the cylinder. In the return movement of the piston this air is compressed and, at the end of the compression stroke, escapes through the by-pass port *G* and the ports *H* and *J* through the piston skirt and the engine casing. The skirt of the piston, in the meantime, seals off the port *E*. The port *J* is of small diameter and its purpose is to relieve the maximum pressure which may develop when the suction tank is full of air. The port is too small in relation to the port *H* to have any substantial effect on the normal operation of the pump.—*June* 1, 1955.

Technical Reports

Comparaison de la Résistance au Choc des Films Lubrifiants. By F. Charron. Publications Scientifiques et Techniques du Ministère de L'Air, No. 298. Paris: Service de Documentation et D'Information Technique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr. 400.—The object of the present research was the study of the protective properties of films of lubricant under steady loads and under shock loading. In the experiments a slowly rotatable lapped journal, 16mm in diameter and 25mm long, was used, against which a half-bearing could be forced by means of a spring-loaded lever. The load could be applied slowly or suddenly, up to a maximum average value of 100 kg per square centimetre. A torque arm device fitted with electrical contacts served to indicate the point at which the resistance to rotation more or less suddenly increased owing to the change from hydro-dynamic to boundary lubrication. The exact time from the moment of application of the load to the moment of seizure was obtained from the trace on a smoked drum rotating at constant speed. The experiments, carried out on three engine and gear oils, as well as on olive oil and vaseline, and with three values of the bearing clearance, showed that the resistance of the film of lubricant to rupture depended on the value of the viscosity under the resisting pressure, and on other factors, but not on the rate of increase of viscosity with pressure.

Etude du Frottement Interne par Elimination Systématique des Forces d'Inertie. By André Brodeau. Publications Scientifiques et Techniques du Ministère de l'Air. No. N.T.54. Paris: Service de Documentation et d'Information Technique de l'Aeronautique. Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr. 300.—The paper describes a method for determining internal friction by eliminating inertia forces and representing the events in terms of new variables. The longitudinal vibrations of a piece of rubber were traced and a displacement-time curve was obtained. At the points of inflection of this curve the inertia forces are zero, giving a linear relationship between the elastic forces and internal friction. The straight line obtained by plotting elastic force against internal friction is the locus which corresponds to all these points of inflection. The author describes a method by which this line may be derived from a knowledge of the maxima and minima of the displacement-time diagram. In spite of inaccuracies due to hysteresis, important information about the internal friction may be obtained in this way.

National Physical Laboratory Report for the Year 1954. London: H.M. Stationery Office. Price 4s.—The National Physical Laboratory has now issued its annual report for 1954. Apart from its original concern, the presentation of fundamental standards and the calibration of secondary standards for outside bodies, the Laboratory carries out a vast amount of work for Government departments and industry, as well as pursuing its own research problems. As the report states, these heavy commitments are being undertaken under conditions of staff shortage, especially when proposed expansions are taken into account, and in order to alleviate the position it is proposed to prune the research programme, as well as to restrict the work to what cannot be adequately carried out elsewhere. During the course of the year under review, the aerodynamics division has continued its studies of high-speed flow, dealing in particular with swept-back and delta wings at high angles of incidence, and with boundary layer control. Wind tunnel tests were also conducted with a model of the proposed Runcorn–Widnes suspension bridge to ensure its freedom from dangerous wind-excited oscillations. The control mechanisms section of the metrology division was combined with the electronics section to form the new division, which will deal with the automatic control of experimental, industrial and administrative operations, and with data processing and computation. The full-scale "Ace" digital computer has been brought into use, the pilot model of which has, in the mathematics division, helped to solve over a hundred problems during the year. A stage has now been reached by the light division in the development of the Merton grating, where its industrial application to infra-red spectroscopy and to length measurement can be envisaged. Some interesting results have been obtained by the metallurgy division concerning the origin of fatigue failure, while the study of low-temperature intercrystalline fracture of certain ferrous alloys has yielded information which it is thought will prove eventually of great importance in industry. Another research, of great practical significance, was conducted to investigate the creep properties of steels which are to be employed in the new power stations of the Central Electricity Authority. Further developments have taken place with auto-collimation and pneumatic gauging. The metrology division has developed methods employing these principles, which permit a test piece to be checked for straightness to $\pm 0{\cdot}00001$in, and internal and external diameters of up to 6in to be measured to the same degree of accuracy. An international comparison of resistance thermometers, in which the physics division has co-operated, has shown provisional agreement about the fundamental interval 0 deg. to 100 deg. Cent. to within $\pm 0{\cdot}001$ deg Cent. The present tendency in therapy to use increasingly powerful radiation led in 1953 to the introduction of an international unit known as the "Rad," which defines dosage in terms of the tissue irradiated. Work is now in progress to define more closely the relation between this unit and the "Roentgen." Finally, much design and experimental work has been carried out by the ship division in connection with a proposed third ship tank and a cavitation tunnel. In concluding this summary, mention should be made of the Laboratory's endeavours to make its services and facilities more widely known, one measure being the appointment of two liaison officers whose task it is to maintain active contact with research organisations and with industry generally.

Launches and Trial Trips

HINDSIA, oil tanker; built at the Barrow yard of Vickers-Armstrongs, Ltd., for Shell Tankers, Ltd.; length overall 555ft 8½in, length between perpendiculars 530ft, breadth moulded 69ft 3in., depth moulded 39ft, deadweight 18,000 tons, speed 14¼ knots; thirty-three cargo oil tanks, one main pump room, four 400 tons per hour turbine-driven cargo oil pumps, two 150 tons per hour stripping pumps, steam deck machinery; two 550kW turbine-driven alternators, one 200kW diesel-driven alternator; one set of two-cylinder double reduction geared Parsons turbine (Pametrada design), service power 7500 s.h.p. at 100 propeller r.p.m., maximum power 8250 s.h.p. at 103 propeller r.p.m., steam supplied at 475 lb per square inch gauge and 790 deg. Fah. by two Foster Wheeler "D" water-tube boilers. Launch, May 24th.

POTOSI, cargo liner; built by the Greenock Dockyard Company, Ltd., for the Pacific Steam Navigation Company; length between perpendiculars 476ft, breadth moulded 66ft, depth moulded to upper deck 40ft 8in, deadweight 11,100 tons on 28ft. mean draught, service speed 16½ knots; twelve passengers; five holds, eight 'tween deck compartments, ten 5-ton, four 10-ton and one 70-ton derricks, electric deck machinery, three 260kW diesel-driven generators; one set of triple-expansion, double reduction geared Parsons turbines, service power 9400 s.h.p. at 108 propeller r.p.m., maximum power 10,340 s.h.p.; two Babcock and Wilcox boilers supply steam at 415 lb per square inch gauge and 750 deg. Fah. Trial, May 24th.

KARMT, oil tanker; built by the Furness Shipbuilding Company, Ltd., for H. M. Wrangell and Co., Norway; length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, deadweight 18,100 tons on 30ft 5¾in summer draught, speed 15 knots; twenty-seven cargo oil tanks, two main pump rooms, four 400 tons per hour cargo oil pumps, two stripping pumps; three 160kW diesel-driven generators; Hawthorn-Doxford single-acting, two-stroke, opposed-piston oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 115 r.p.m.; two Scotch boilers. Launch, May 24th.

FOSNA, oil tanker; built by Smith's Dock Company, Ltd., for A/S J. Ludwig Mowinckels Rederi; length overall 528ft 10in, length between perpendiculars 500ft, breadth moulded 69ft 6in, depth moulded 38ft, deadweight 16,400 tons on 29ft 9½in draught, loaded speed 14 knots; twenty-seven cargo oil tanks, two cargo pump rooms, four 500 tons per hour cargo oil pumps, two 100 tons per hour stripping pumps; steam deck machinery, two 250kW diesel-driven generators; Kincaid-B. and W. two-stroke diesel engine, 5500 b.h.p. at 110 r.p.m.; one Spanner "Upflow" exhaust gas boiler, two multi-tube cylindrical boilers. Trial, May.

BARON GLENCONNER, cargo liner; built by the Caledon Shipbuilding and Engineering Company, Ltd., for H. Hogarth and Sons, Ltd.; length overall 461ft, length between perpendiculars 430ft, breadth moulded 58ft, depth moulded to shelter deck 37ft 6in, load draught 25ft 3in, deadweight 9300 tons; five cargo holds and 'tween decks, ten 5-ton derricks, steam deck machinery; two 100kW steam-driven generators; Kincaid steam reciprocating engine and Bauer-Wach turbine, 3350 i.h.p.; trial speed 12¼ knots. Launch, June 3rd.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

CHEMICAL SOCIETY

Wed. to Fri., July 13th to 15th.—The University College of the South West of England, Prince of Wales Road, Exeter, Symposium on "Recent Work on Naturally Occurring Nitrogen Heterocyclic Compounds."

INSTITUTE OF BRITISH FOUNDRYMEN

Sun. to Sat., June 19th to 25th.—LONDON: Twenty-second International Foundry Congress.

INSTITUTE OF INDUSTRIAL ADMINISTRATION

Wed., June 22nd.—LONDON BRANCH: Fyvie Hall, The Polytechnic, Regent Street, London, W.1, Higher Management Lectures, "The Practice of General Management," 6.30 p.m.

INSTITUTE OF PETROLEUM

Thurs., June 30th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Four papers outlining "The Story of the Co-ordinating Research Council," by M. K. McLeod, T. B. Rendel, E. S. Macpherson and W. J. Sweeney, 3.30 and 5.30 p.m.

INSTITUTE OF PHYSICS

Thurs., June 23rd.—NON-DESTRUCTIVE TESTING GROUP: Royal Technical College, Glasgow, Annual General Meeting, 9 a.m.

INSTITUTION OF HIGHWAY ENGINEERS

Fri., July 1st.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, Annual General Meeting, followed by Film, "Highways for To-morrow," 5.30 p.m.

INSTITUTION OF MINING ENGINEERS

To-day, June 17th.—Summer Meeting in Edinburgh.

SOCIETY OF CHEMICAL INDUSTRY

Mon. to Sat., July 11th to 16th.—The University, Edgbaston, Birmingham, 15, Seventy-Fourth Annual Meeting.

WOMEN'S ENGINEERING SOCIETY

Wed., June 22nd.—LONDON BRANCH: 35, Grosvenor Place, London, S.W.1, Annual General Meeting, 7 p.m.